2D Kinematics
(without a coordinate system)

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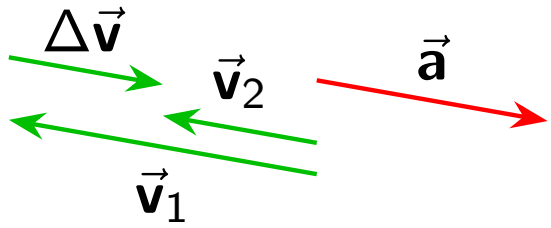
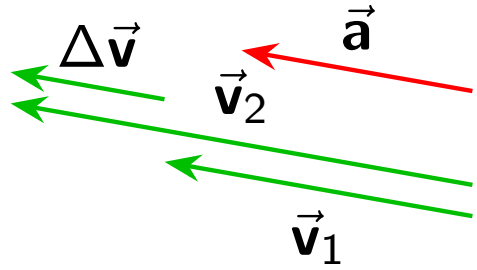
Two ways velocity can change

1. The magnitude of velocity can change (= speed can change).



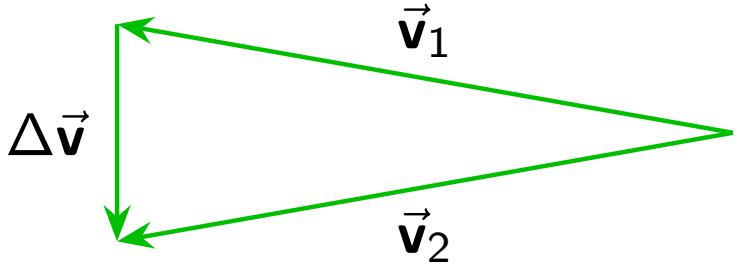
slowing down



speeding up

   - This is a form of acceleration.

2. The direction of velocity can change.

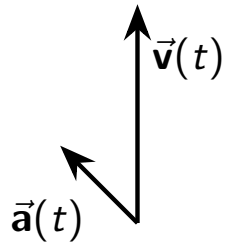
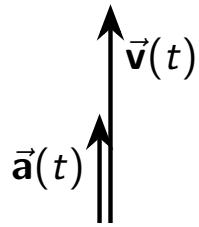
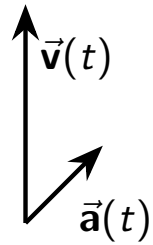
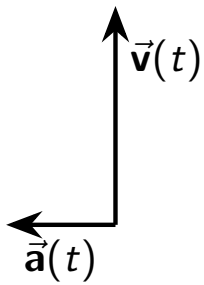
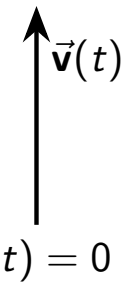
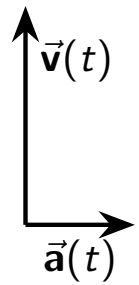
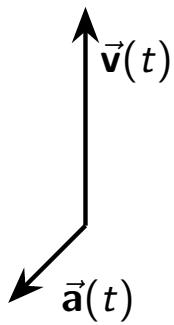
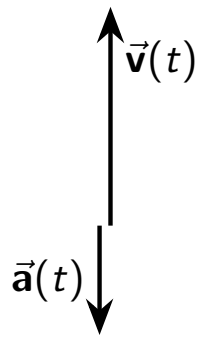
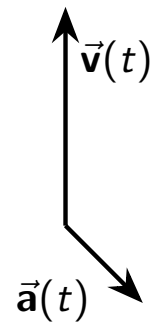


   - This is a form of acceleration (acceleration is not zero).

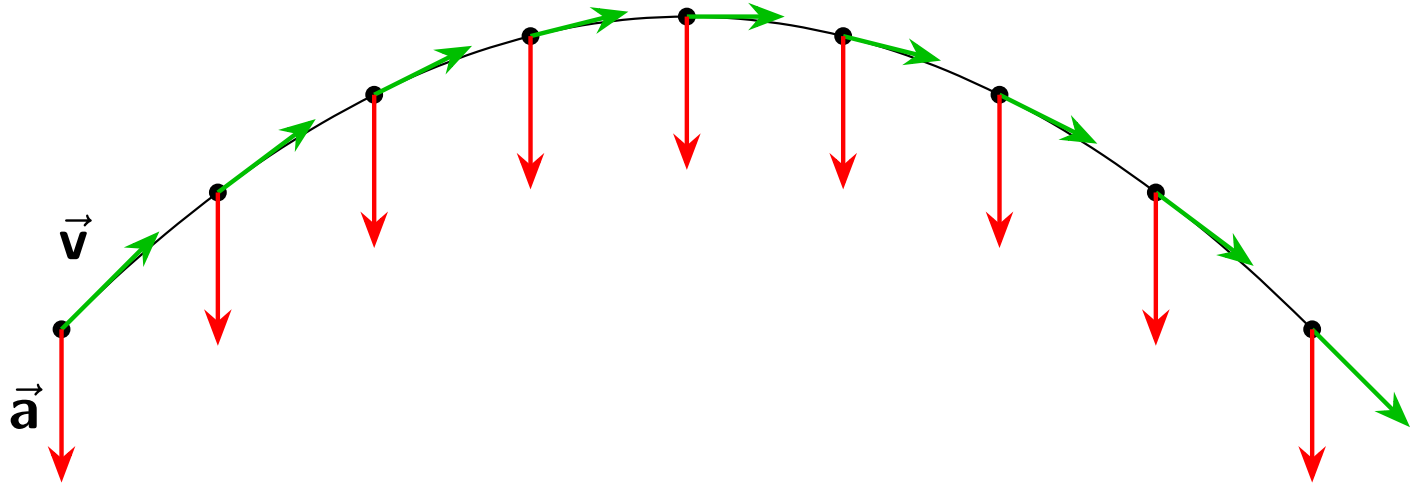
- Both ways of changing can happen at the same time.

Speed, direction, and acceleration

	Speed constant	Speed changing
Direction constant	$\vec{\mathbf{a}} = 0$	$\vec{\mathbf{a}} \neq 0$
Direction changing	$\vec{\mathbf{a}} \neq 0$	$\vec{\mathbf{a}} \neq 0$

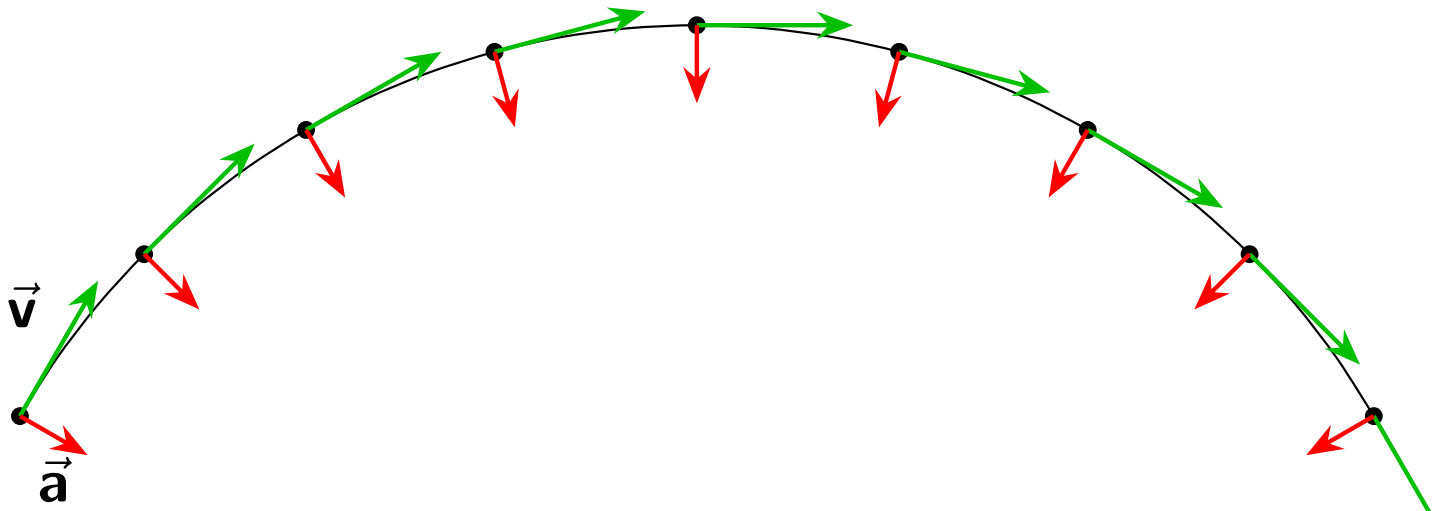
 increase speed turn left	 increase speed go straight	 increase speed turn right
 maintain speed turn left	 maintain speed go straight	 maintain speed turn right
 decrease speed turn left	 decrease speed go straight	 decrease speed turn right

Projectile Motion



- Acceleration is constant
- Speed is not constant (acceleration is only perpendicular to velocity at the very top)

Circular Motion



- Acceleration is not constant
- Speed is constant, because acceleration is always perpendicular to velocity

Kinematics relationships

- Constant velocity $=$ Zero acceleration
- Constant speed $\neq$ Zero acceleration
- Constant speed $=$ acceleration has no component in the direction of velocity
- Nonzero acceleration $=$ changing velocity
- Nonzero acceleration $\neq$ changing speed
- Changing speed $\Rightarrow$ nonzero acceleration
- Zero acceleration $\Rightarrow$ constant speed
- "Velocity is negative" only makes sense in one dimension (and even then, only in the context of a coordinate system). Northwest motion, for example, has both positive and negative components.

Kinematics quantities

Quantity	symbol	vector/scalar	unit
Displacement	$\vec{\mathbf{D}}$	vector	m
Distance		scalar	m
Velocity	$\vec{\mathbf{v}}$	vector	m/s
Speed	v	scalar	m/s
Acceleration	$\vec{\mathbf{a}}$	vector	m/s^2
Time	t	scalar	s

Secret: Distance and speed are secondary. Our brains apprehend them easily, but the theory doesn't care about them.

PVA Diagrams

- We are going to make diagrams that show the position, velocity, and acceleration of an object over time.
- The position of the object will be shown as a dot. There will be several dots showing the position of the object at several different times.
- Between each pair of adjacent dots, we will draw a *displacement vector*. The displacement vector is proportional to the *average velocity*. This implies that the displacement vector points in the same direction as the average velocity vector.
- We will use the acceleration to change the velocity. The acceleration vector points in the same direction as the *change in velocity* vector.