Particle Kinematics

Course overview: **Dynamics = Kinematics + Kinetics**

Kinematics: **The *description* of motion (position, velocity, acceleration, time) without regard to forces.**

Exam 1: (Chapter 12) Particle Kinematics

Exam 2: (Chapter 16) Rigid Body Kinematics

Kinetics: **Determining the *forces* (based on F=ma) associated with motion.**

Exam 3: F=ma (Particles and Rigid Bodies)

Exam 4: Integrated forms of F=ma
(Work-Energy, Impulse-Momentum)

Particle: **A point. Insignificant dimensions. Rotation not defined.**

Rigid Body: **Infinite number of points. A RB may rotate, with *angular* displacement, velocity and acceleration.**

Kinematic Variables

Particle kinematics involves describing a particle's position, velocity and acceleration versus time.

Kinematic Variables		
Description	**Vector**	**Scalar**
Position	$\vec{r}$	s
Velocity	$\vec{v}$	v
Acceleration	$\vec{a}$	a
Time	t	t

Defining Kinematic Equations

Three basic kinematic equations we will use all semester.

(1) Velocity is the time rate of change of position.

(2) Acceleration is the time rate of change of velocity.

(3) a ds = v dv along a given path. (Obtained from (1) and (2))

For now, for simplicity, **we'll use the scalar version** of the equations.

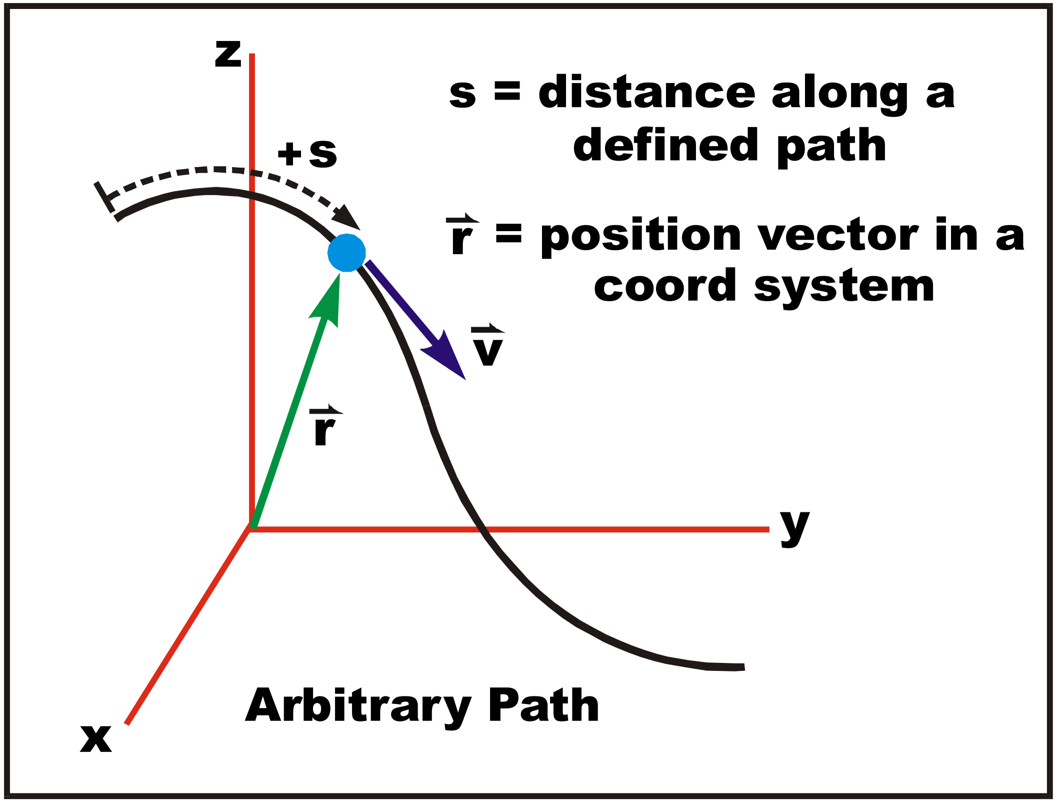
The **scalar eqns** only apply to a known path, and accel is along the path only.

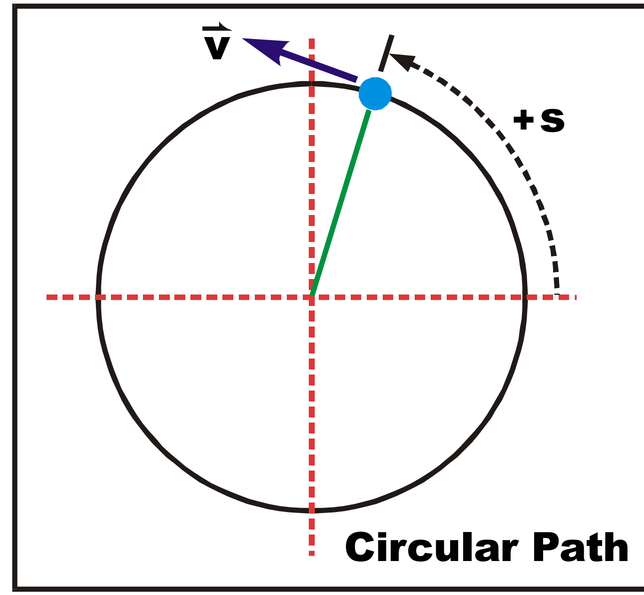
Elim dt from ① and ② gives ③ a ds = v dv

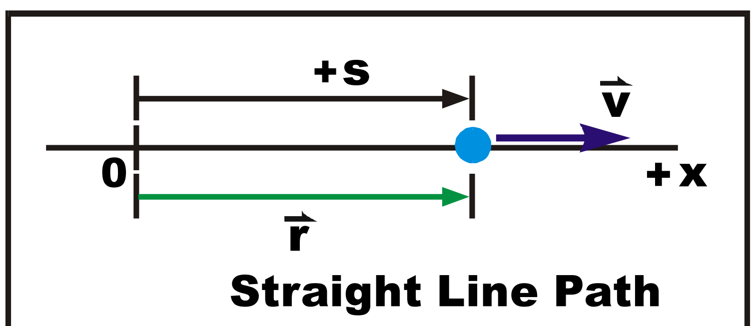
Defining Kinematic Eqns	
Scalar	**Vector**
① $v = \frac{ds}{dt}$	$\vec{v} = \frac{d\vec{r}}{dt}$
② $a = \frac{dv}{dt}$	$\vec{a} = \frac{d\vec{v}}{dt}$
③ $a\,ds = v\,dv$	

The **vector eqns** apply to any path in any coordinate system. The position vector r will take on different forms in different coord systems, but the v and a definitions still apply.

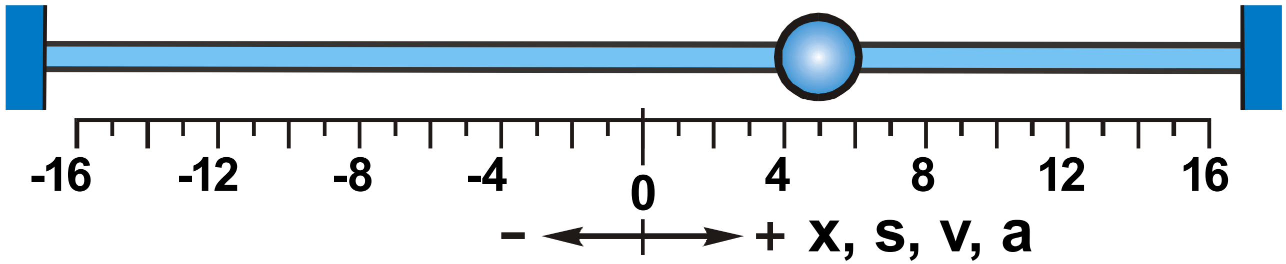
Various Simple Coordinate Systems





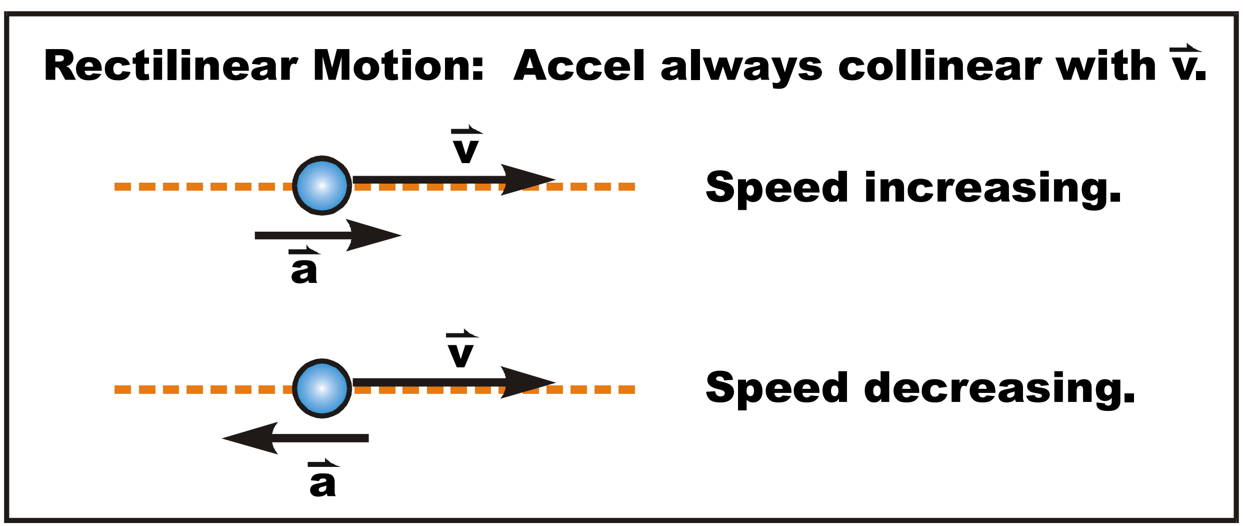


Particle Straight Line (Rectilinear) Motion



Typical Rectilinear Motion Coordinate System

Key feature of straight line motion: Acceleration is always collinear with the velocity. Examples:



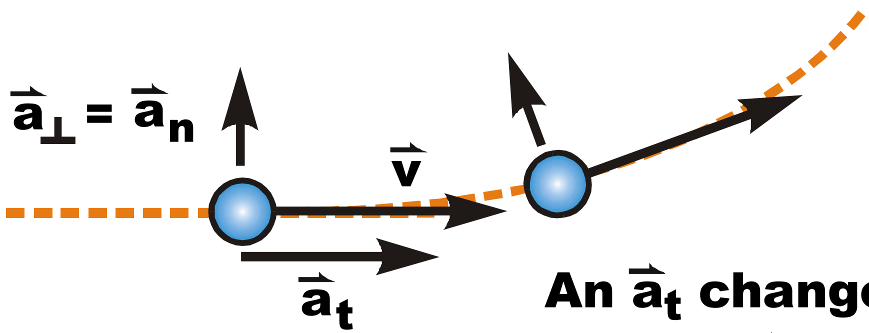
Particle Straight Line (Rectilinear) Motion

Key feature of straight line motion: Acceleration is always collinear with the velocity.

What if accel is NOT collinear with the velocity? You would have curvilinear motion (to be covered next week).

What if the accel is NOT collinear with $\vec{v}$?

What if there is an accel component $\perp$ to $\vec{v}$?



An $\vec{a}_t$ changes the length (speed) of the $\vec{v}$ vector.

An $\vec{a}_n = \vec{a}_\perp$ changes the direction of the $\vec{v}$ vector (a curve)!

Particle Straight Line Motion

Straight Line Motion Cases:

(1) a = constant
(2) a = f(t)
} **Today!**

(3) a = f(v)
(4) a = f(s)
(5) v = f(s)
...etc...
} **Next class.**

Various combinations of the basic kinematic variables a, v, s, and t.

They all can be expressed as functions of another variable.

Straight Line Motion: Accel = Constant Case

The defining kinematic equations may be integrated for accel = constant to get the familiar equations shown below. Memorize these! You will use them often. Use them ONLY for accel = constant. (Do not plug an accel function into these eqns.)

Accel = Constant Equations	
Defining Eqns	**Integrated (a = const)**
① $a = \frac{dv}{dt}$	$v = v_0 + at$
② $v = \frac{ds}{dt}$	$s = s_0 + v_0 t + \frac{1}{2}at^2$
③ $a\,ds = v\,dv$	$v^2 = v_0^2 + 2a(s - s_0)$

Memorize these!

Use only for a = const !

Look for this wording:

"accelerates uniformly"

"accelerates at 4 m/s^2 "

"constant acceleration "

Straight Line Motion:
Accel = Constant Case

Accel = Constant Equations	
Defining Eqns	**Integrated (a = const)**
① $a = \frac{dv}{dt}$	$v = v_0 + at$
② $v = \frac{ds}{dt}$	$s = s_0 + v_0 t + \frac{1}{2}at^2$
③ $a\,ds = v\,dv$	$v^2 = v_0^2 + 2a(s - s_0)$

Straight Line Motion: Accel = Constant Case

See the example problems with this lecture for an example (or two) of acceleration = constant problems.

Straight Line Motion: a = f(t) Case

See the example problems with this lecture for an example plus key principles you need to know.

Next Class: Additional accel = function cases….

(3) a = f(s)

(4) a = f(v)

(5) v = f(s)

…etc…