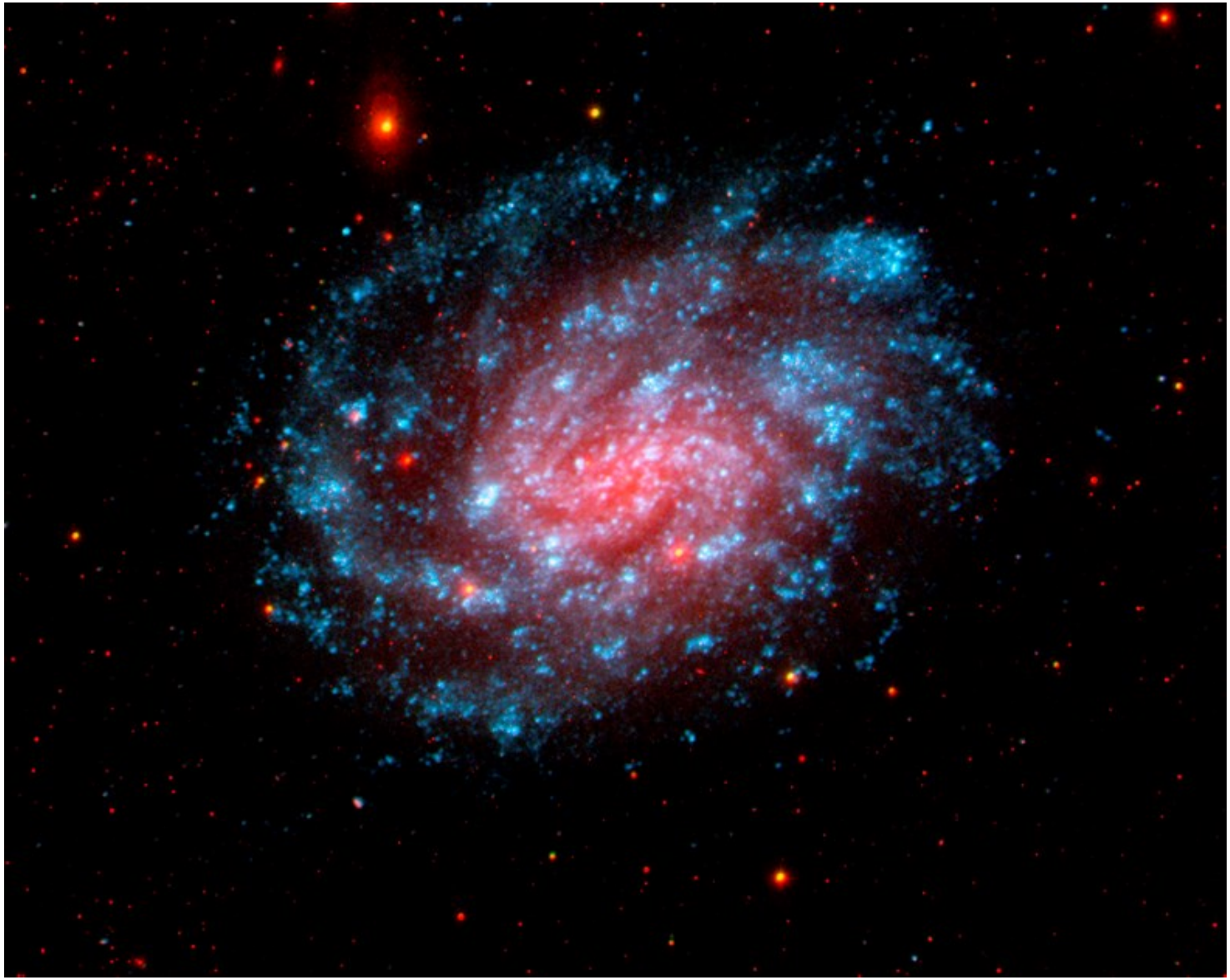
Lecture 1: Course introduction
Motion in one dimension

- Semester preview
- Motion along a straight line
- Position and displacement
- Velocity and speed
- Acceleration as derivative of velocity with respect to time
- Interpret the sign of velocity and acceleration

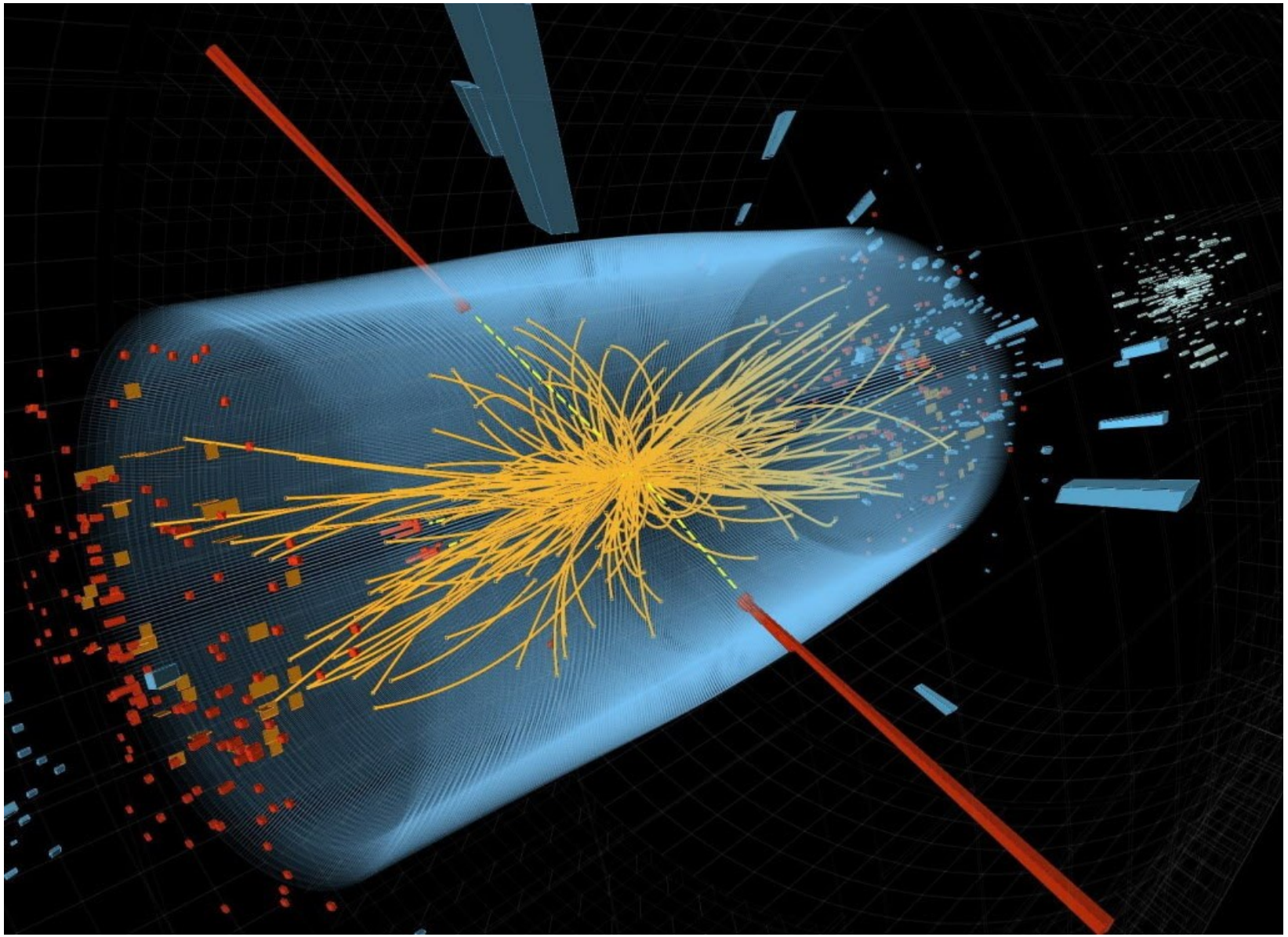
What is physics?

Most fundamental of sciences

Behavior and structure of matter



Galaxy NGC 300, seven million lighters away, constellation Sculptor. Courtesy of NASA.



High energy proton collision in the LHC. © CERN

Why study physics?

- Required for major
- Find out how the world works
- Because it is FUN

Demonstrations

Topic overview

Mechanics

- Motion of macroscopic objects
- Forces, friction, circular motion
- Energy and momentum
- Motion of planets
- Rotational motion
- Oscillations and waves
- Fluids

Thermodynamics

Honda cog ad video

A few tools:

- SI system of units, unit conversions
- Scientific notation
- Prefixes: micro, milli, centi, kilo…
- Estimates

Please review on your own as needed.
See Ch. 1, Sec. 1.1-1.6

Basic math skills* required in this course

- Linear equations, systems of linear equations
- Quadratic equations
- Basic trigonometry: SOHCAHTOA, Pythagoras
- Calculus 1: derivatives/integrals

Note: Calc 1 is a prerequisite for this course. If you have not taken calc 1, you should drop the class.

*Homework # 1
will help you review

- Vectors (will be covered in lecture 3)

Kinematics: Describing Motion

Consider object as point mass → only translation

Things to know about a moving object:

Where is it? ➔ Position

How fast is it moving and in which direction?
➔ Velocity

How do speed and direction of motion change?
➔ Acceleration

Position

- In reference to some coordinate system
- numerical value *x*
- *x*(t) is location of particle as a function of time
- Initial position: $x_0 = x(t_0)$ *

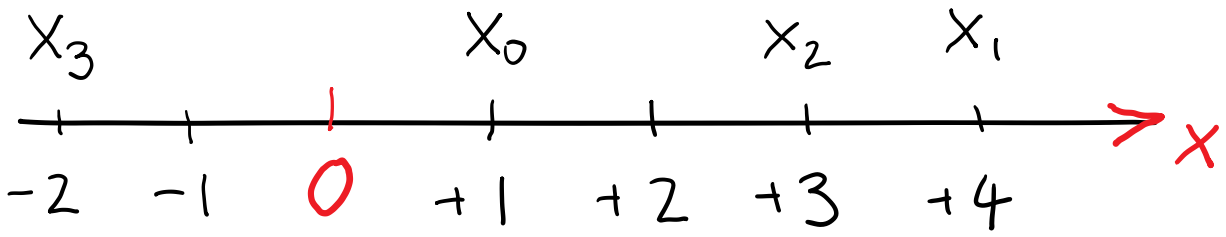
* Does not mean $x_0 = 0$

Showing position

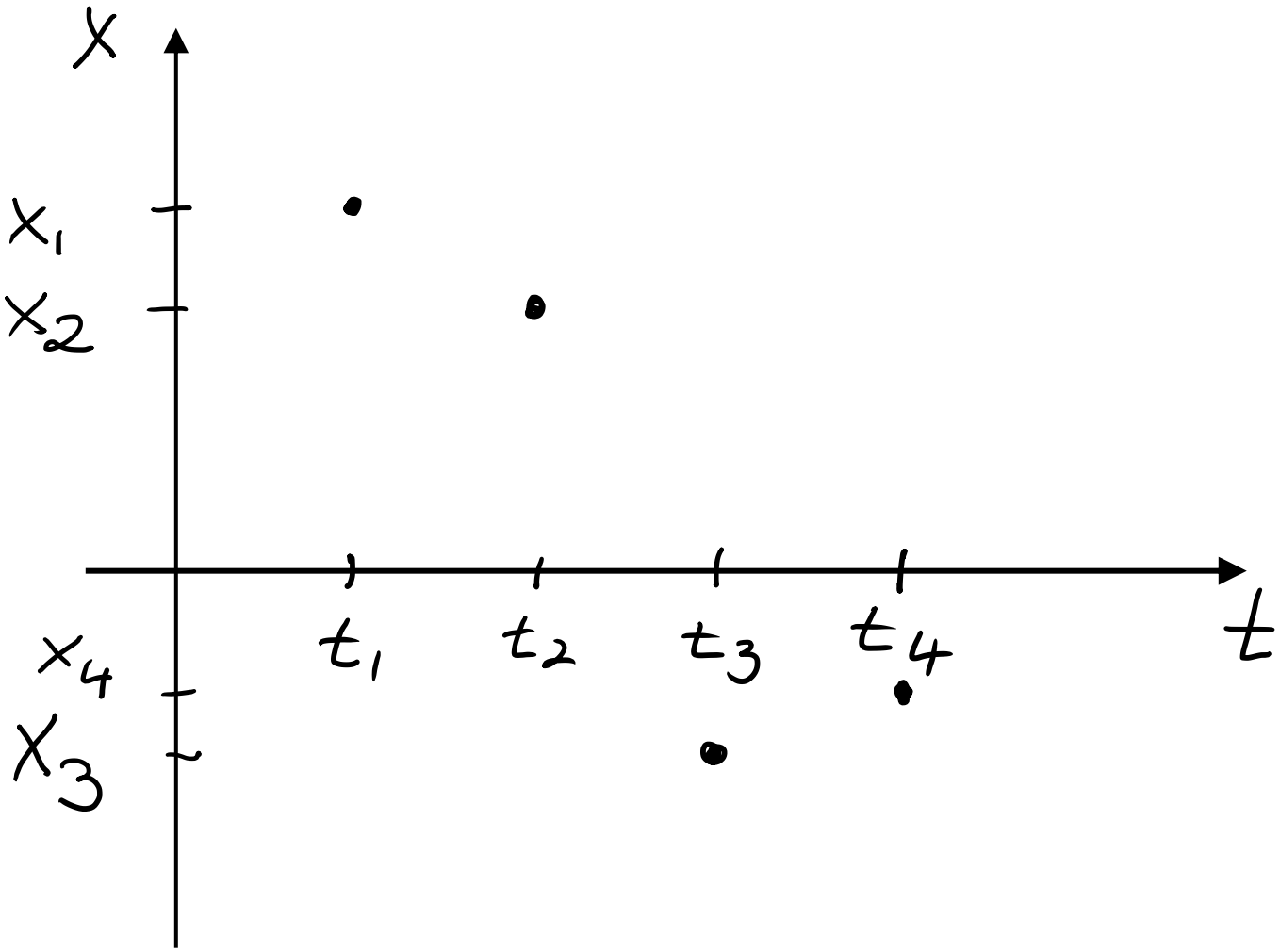
With respect to a coordinate system:

x-axis with origin and a positive direction (arrow)

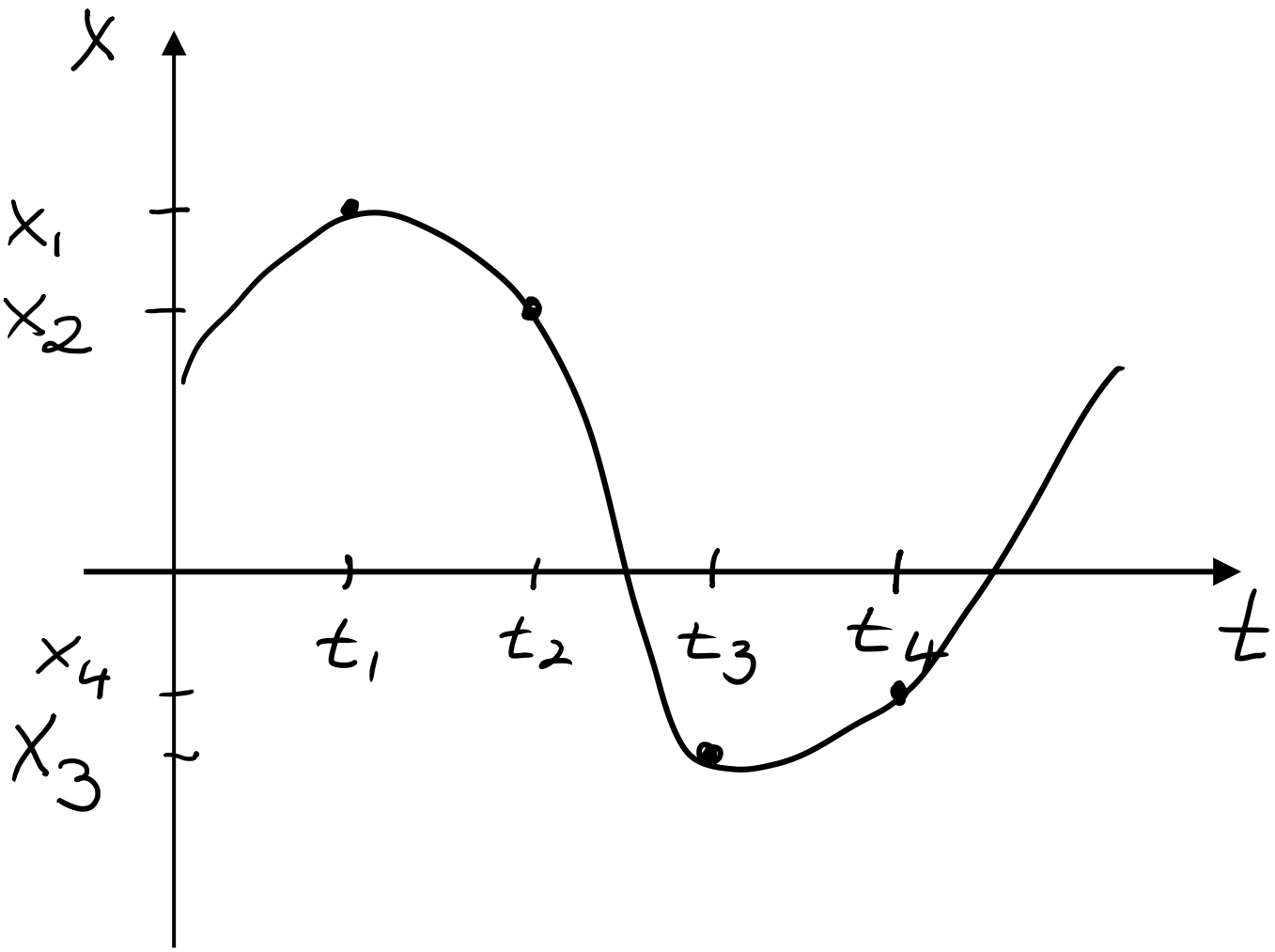
Mark position at certain times:



Position versus Time Graphs



Position versus Time Graphs



Displacement

Displacement = Change in position: *

$$\Delta x = x_f - x_i$$

* Change (upper case delta Δ) is the final value of a quantity minus the initial value.

Δx can be positive or negative ⟶ direction

Displacement is not the same as distance traveled!

Speed and velocity

"I am currently going at 25 mph"
= instantaneous speed

Together with information about direction:
"I am currently going at 25 mph North on Pine Street"
= instantaneous **velocity**

"I drove the 60 miles in one hour"
= average speed, distance per time

Average velocity

$$average\ velocity = \overline{v_x} = \frac{displacement}{time\ interval} = \frac{\Delta x}{\Delta t}$$

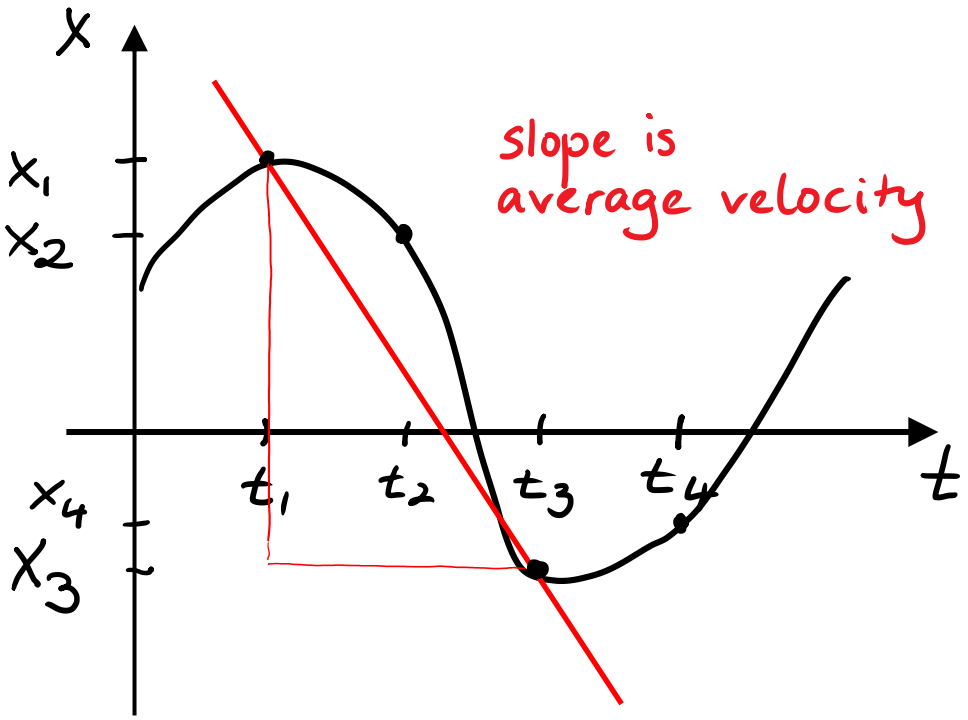
unit: $\frac{m}{s}$

* The subscript x is very important!

$\overline{v_x} > 0$: object moves in the positive x-direction

$\overline{v_x} < 0$: object moves in the negative x-direction

Average velocity and x-t graph

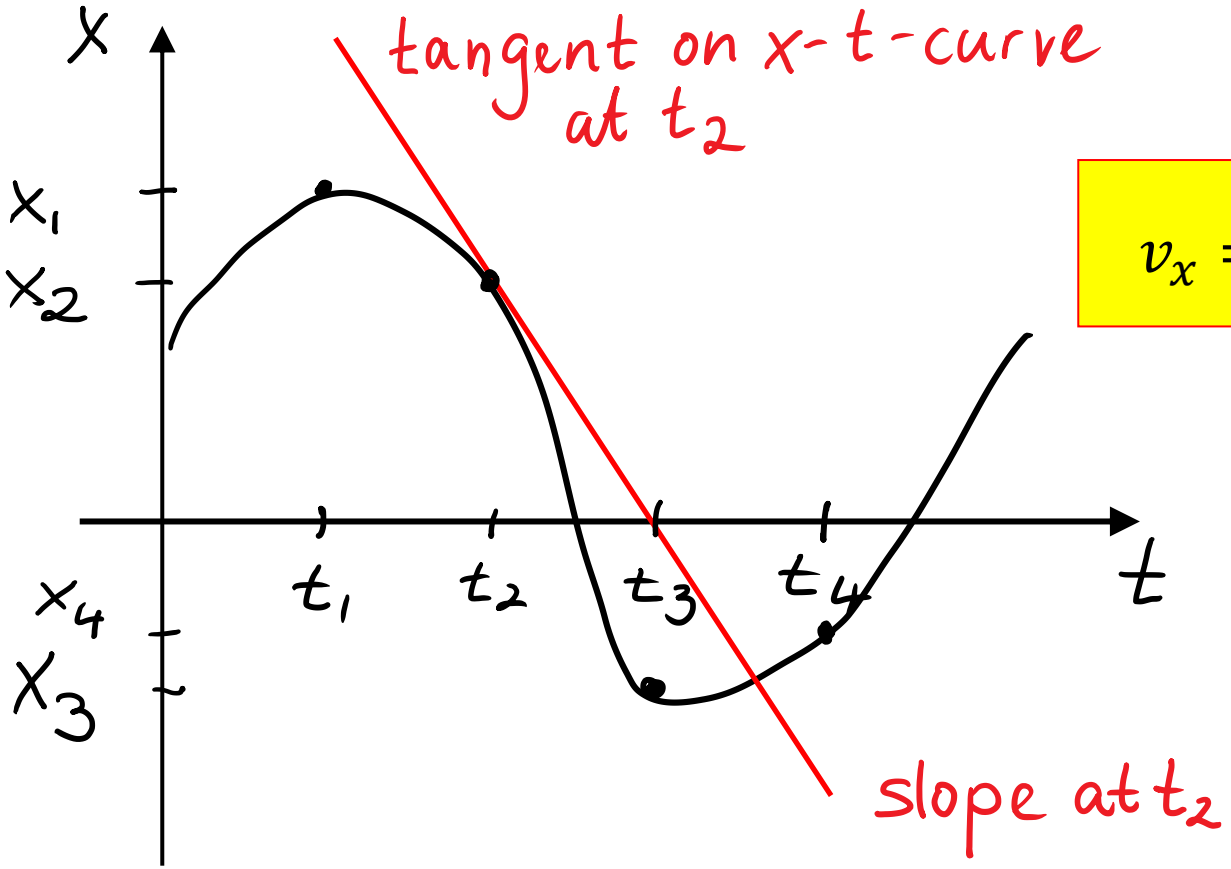


Average velocity between t_1 and t_3:

$$\overline{v_x} = v_{av-x} = \frac{x_3 - x_1}{t_3 - t_1}$$

In this example:
$\overline{v_x}$ is negative.
Object moves to smaller value of x.

Instantaneous velocity



$$v_x = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt}$$

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

Speedometer shows
absolute value
of instantaneous velocity

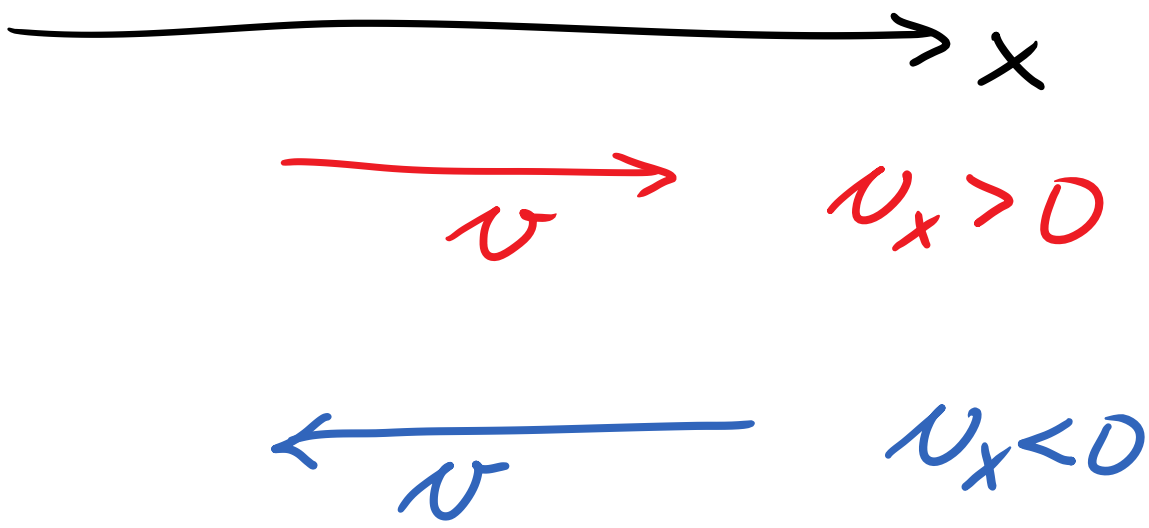
$v = |v_x|$ = speed

always positive

Direction of velocity

v_x >0: object moves in the positive x-direction

v_x <0: object moves in the negative x-direction



Acceleration

Acceleration: how fast velocity changes,
time rate of change of velocity

$$a_x = \frac{dv_x}{dt} = \frac{d^2x}{dt^2}$$

Slope of v_x vs t graph

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

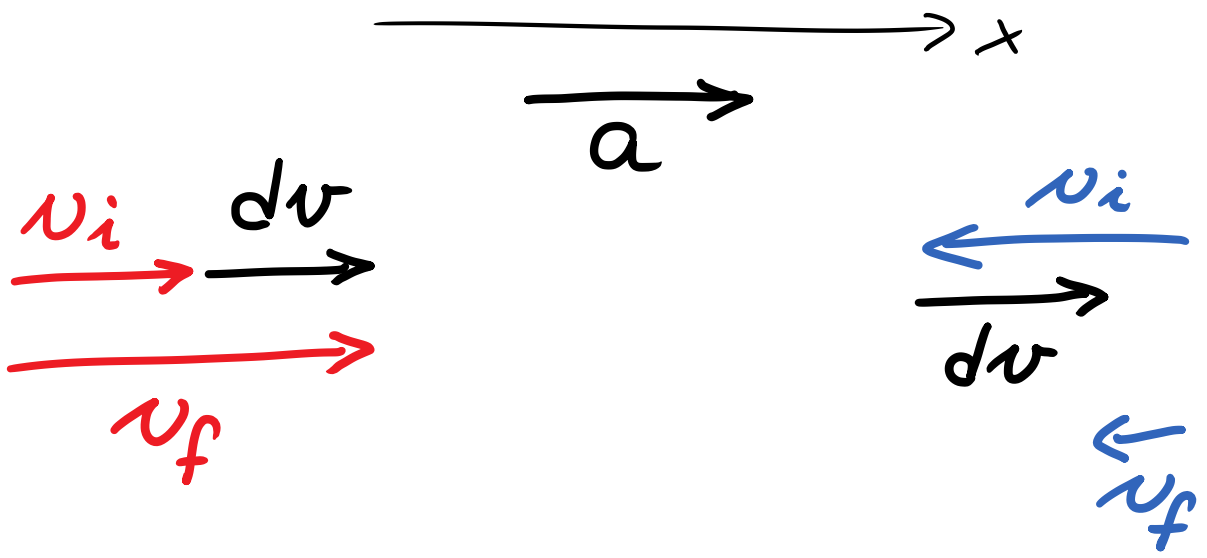
Acceleration produces change in velocity: $dv_x = a_x dt$

Signs of acceleration and velocity

If $a_x > 0$ and thus $dv_x = a_x dt > 0$:

if v_x >0 speed up

if v_x <0 slow down

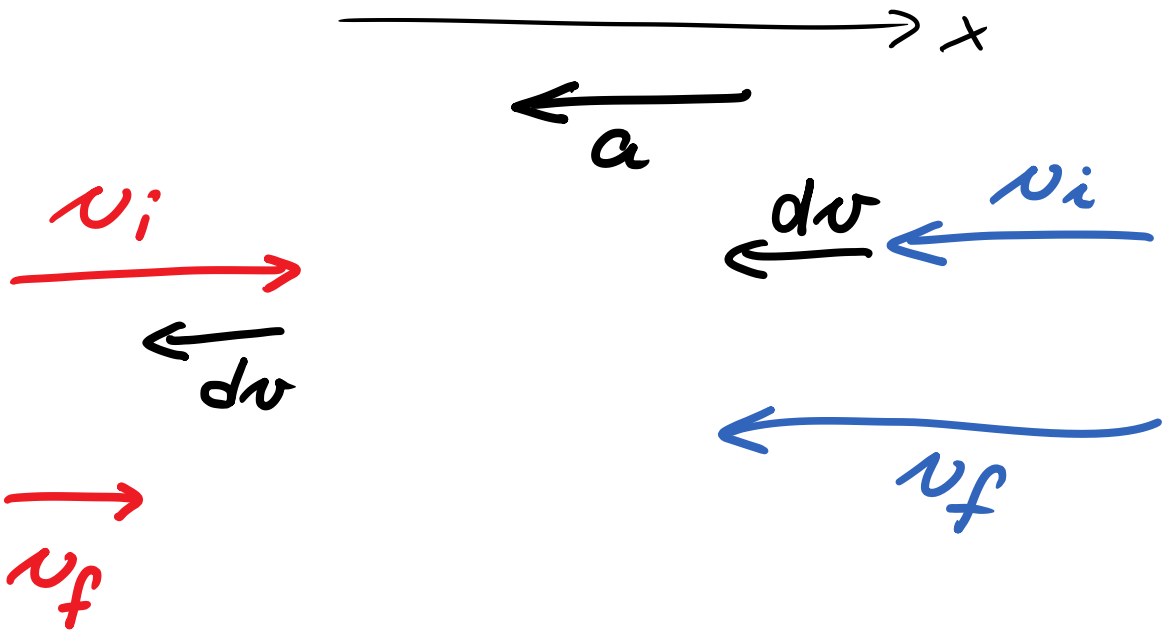


Signs of acceleration and velocity

If $a_x < 0$ and thus $dv_x = a_x dt < 0$:

if v_x >0: slow down

if v_x <0: speed up



Motion diagrams

http://phet.colorado.edu/en/simulation/moving-man

$$x_0 = 0, v_{0x} = +4\frac{m}{s}, a_x = -2\ m/s^2$$