Phys 131 2024

Lecture 2

Weds: Discussion / quiz

131 Exercises: 4, 10, 12, 13, 17, 18, 21, 23

Quiz (5pts) Eventual total 600pts

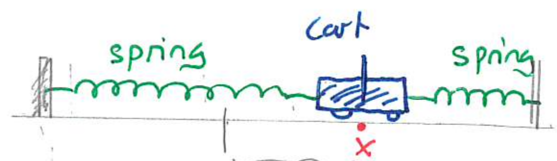
Fri: Warm Up 1 D2L

Reading quiz (2pts)

Motion: Kinematics

The core question that classical physics addresses is how an object moves. For example, consider a cart oscillating on a track. We then aim to:

Describe system + interactions — cart specifics, spring specifics



↓

Describe state of system at an initial moment — e.g. released from rest at x

↳ What will be state of motion at any later moment? — How long to return

Kinematics provides the language to describe how motion occurs. For an object moving in one dimension it uses:

1) position (describes location) ⇝ use a frame of reference calibrated in meters [m]

2) time (describes instants) ⇝ use a standard clock calibrated in seconds [s]

Kinematics provides various ways to represent motion.

Motion diagram

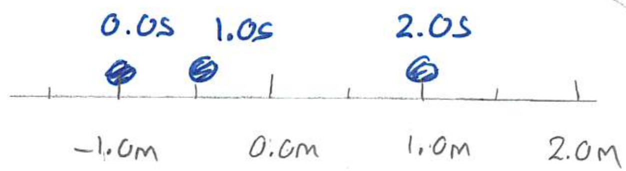


Chart position along axis

Data

time t	position x
0.0s	-1.0m
1.0s	-0.5m
2.0s	1.0m

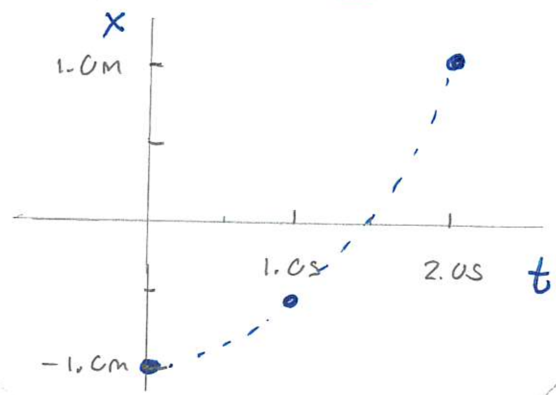
Function representing x vs t

$x = \frac{1}{2}t^2 - 1$

OR

$x(t) = \frac{1}{2}t^2 - 1$

Graph of position vs. time



Speed and velocity

Physics does not automatically provide position and we must often work via intermediate entities - speed, velocity and acceleration.

The first of these is

speed ~ rate at which distance is covered

DEMO: PhET Moving Man

- Charts tab
- set $x_0 = -8$ $\quad v_0 = 3$
  $v_0 = 1$
- Describe motion in words

More precisely:

During some time interval

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

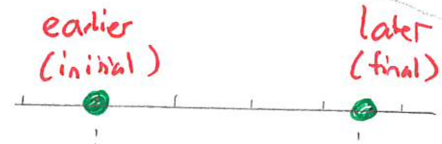
units: m/s

This does not account for the direction of motion, which will be important for subsequent physics. So we extend the idea of speed to a new concept:

velocity ~ rate of change of position

A preliminary definition is:

Observe object over a time interval, focus on the beginning + end of the interval. Record the position and time data at these two instants



position	x_i	x_f
time	t_i	t_f

<u>Displacement</u> of object during the interval → change in position

$$\Delta x = x_f - x_i$$

units [m]

→ <u>Average velocity</u> during this interval:

$$V_{avg} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i}$$

(from t_i to t_f)

units [m/s]

FRAMEWORK for DEFINING AVERAGE VELOCITY

<u>Quiz 1</u> 90% // 95%

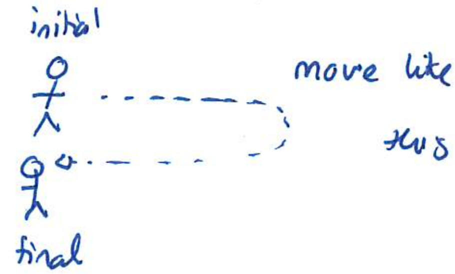
<u>Quiz 2</u> 60% – 60% // 60% – 90%

<u>Quiz 3</u> 70% – 90% // 70% – 90%

Notes:

1) average velocity and average speeds are different. In the illustration

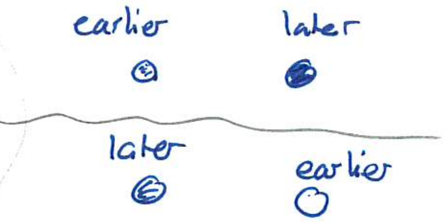
$v_{avg} = 0\,m/s \qquad s > 0\,m/s$



2) velocity has a sign

v_{avg} positive ⇒ displacement is to right

v_{avg} negative ⇒ displacement is to left



3) "average" is part of the terminology and it does not mean take an average.

Uniform motion

The simplest non-trivial case of motion is that where, at all times

* the object moves in the same direction
* the object moves at a constant rate

This is called uniform motion. For uniform motion.

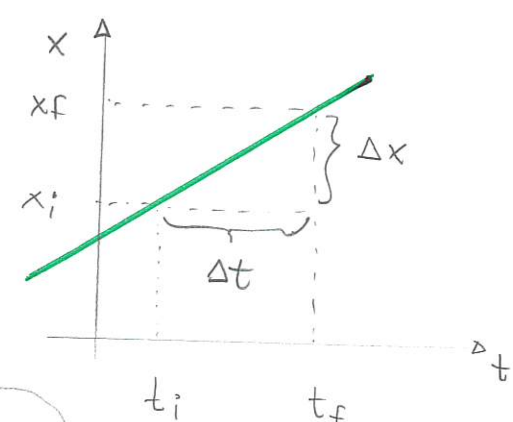
1) the average velocity is the same regardless of the interval used to calculate it.

Quiz 4 60% → 80%

2) a graph of position versus time

* is a straight line
* has slope

$$\frac{rise}{run} = \frac{\Delta x}{\Delta t} = v_{avg}$$



⇒ average velocity = slope of position vs. time

3) displacement can be determined via

$$\Delta x = v_{avg} \Delta t$$

Derivation: $v_{avg} = \frac{\Delta x}{\Delta t} \Rightarrow v_{avg} \Delta t = \Delta x.$

4) speed is the magnitude (no ± sign) of velocity.

Piecewise uniform motion

Sometimes the motion is uniform over one interval and then changes to a different uniform motion over another interval. We can do the analysis in a piecewise fashion