Physics 101 Lecture 2
Kinematics: Motion in 1-Dimension

FAQs

- *How can I register my clicker for course?*

A: go through the course web site. Do not go to iclicker.com.

- *Can I switch discussion/lab sections?*

A: sorry, no, unless you can find a section with open seats. We only have a limited number of physical seats in each section.

- *How do I buy the textbook?*

A: First, the textbook is **not** required for the course, but it may be useful. If you **do not** want the textbook you can just subscribe to flipit physics for $40. If you **do** want the textbook go to the bookstore and buy the card for $60. You can use the code on the card to register for flipit and the ebook.

- I switched sections. Do I need to re-register my iclicker?

No!

FAQs

- *The lecture hall is overcrowded and I can't see.*

A: It is pretty crowded. There are lots of empty seats, though, so please come down and muscle your way in.

- *I want to go to the other lecture!*

A: For the moment you are welcome to do this. If one or the other lecture becomes overcrowded I will turn off this option. Your iclicker points will be counted seamlessly.

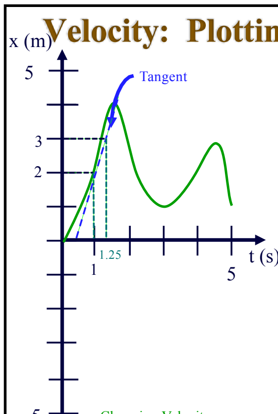
- *Where and when are office hours?*

A: Location is in the TA Commons, room 279 Loomis (NE corner of the second floor). The times are on the web page, and are between 10am and 7pm on Tu and W.

Kinematics: Velocity

- Velocity: the rate of change of position
  - » $v = \Delta x/\Delta t$.
  - » average
  - » instantaneous

Velocity: Plotting Position and Time



- Instantaneous Velocity:

  the slope of *tangent* line *at any point* on a position-time graph

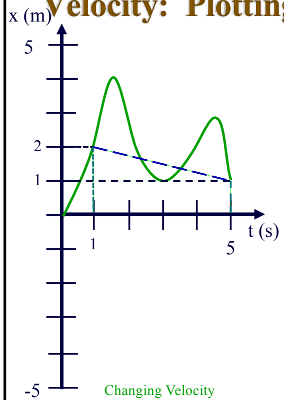
- Example:

  What is the *instantaneous velocity*:

  $x = 2$ m and $t = 1$ s?

- $v = \Delta x_{tan}/\Delta t_{tan}$
  - $\Delta x_{tan} = (3 - 2)$ m
  - $\Delta t_{tan} = (1.25 - 1)$ s
  - $v = \frac{1 \text{ m}}{0.25 \text{ s}} = 4$ m/s

Velocity: Plotting Position and Time



Changing Velocity

- Example:

  What is the *average velocity* between : $t = 1$ s and $t = 5$ s?

- $\Delta v = \Delta x / \Delta t$
  - ➡ $\Delta x = (1 - 2)$ m
  - ➡ $\Delta t = (5 - 1)$ s
  - ➡ $v = \frac{-1\ \text{m}}{4\ \text{s}} = -0.25 \frac{\text{m}}{\text{s}}$
  - ➡ What's "–" mean?

Kinematics: Acceleration

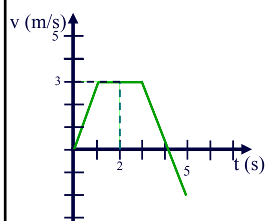
➡ Acceleration: the rate of change of velocity

» $a = \Delta v / \Delta t$

» average

» instantaneous

Acceleration: Plotting Velocity and Time



- Slope:

  Instantaneous acceleration:

  $a = \left(\frac{\Delta v}{\Delta t}\right)$ *for small* Δt

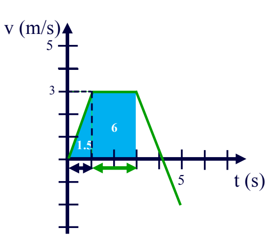
- Example:

  Velocity at $t = 2$

  ➡ $v(2) = 3$ m/s

What's acceleration at t=2?

Acceleration: Plotting Velocity and Time



- Area:

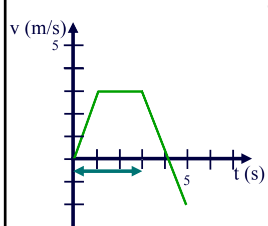
  Displacement: $\Delta x = v \Delta t$

- Example:

  Find the *displacement* between: $t = 0$ s and $t = 3$ s

  - ➡ $t = 0$ s to $t = 1$ s
    - » $\Delta x_1 = \frac{1}{2}\left(3\frac{\text{m}}{\text{s}}\right)(1\ \text{s}) = 1.5$ m
  - ➡ $t = 1$ s to $t = 3$ s
    - » $\Delta x_2 = \left(3\frac{\text{m}}{\text{s}}\right)(3\ - 1\ \text{s}) = 6$ m
  - ➡ $\Delta x = \Delta x_1 + \Delta x_2 = 7.5$ m

Acceleration: Plotting Velocity and Time



- Average Velocity:

  $\Delta v = \Delta x / \Delta t$

- Example:

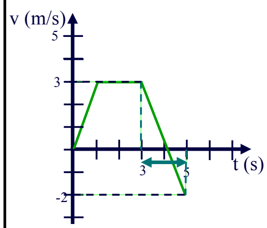
  Average velocity between

  $t\ =\ 0$ s and $t\ =\ 3$ s

  ➡ $\Delta x = 7.5$ m, $\Delta t = 3$ s

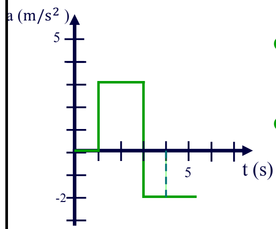
  ➡ $\Delta v = \frac{7.5}{3}\frac{\text{m}}{\text{s}} = 2.5$ m/s

Acceleration: Plotting Velocity and Time



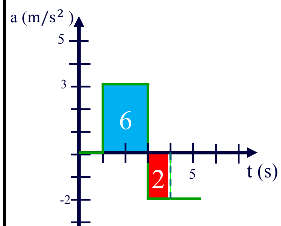
- Average Acceleration:
  $\Delta a = \Delta v/\Delta t$
- Example:
  Average acceleration between
  $t = 3$ s and $t = 5$ s
  - ➡ $\Delta v = (-2 - 3)\frac{\text{m}}{\text{s}} = -5\frac{\text{m}}{\text{s}}$
  - ➡ $\Delta t = (5 - 3)\text{s} = 2\text{ s}$
  - ➡ $\Delta a = -\frac{5\frac{\text{m}}{\text{s}}}{2\text{ s}} = -2.5\text{ m/s}^2$

Graphical Representation of Acceleration: Plotting Acceleration and Time



- Slope:
  $a = \Delta v/\Delta t$
- Example: Acceleration at $t = 4$ s:
  - ➡ $a(4\text{ s}) = -2\frac{m}{s^2}$

Acceleration: Plotting Velocity and Time

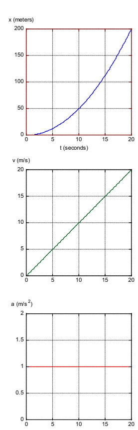


- Area:
  $\Delta v = a\,\Delta t$
- Example: Change in velocity between $t = 1$ s and $t = 4$ s
  - ➡ $t = 1$ s to $t = 3$ s
    - » $\Delta v_1 = \left(3\frac{\text{m}}{\text{s}^2}\right)(2\text{ s}) = 6\text{ m/s}$
  - ➡ $t = 3$ s to $t = 4$ s
    - » $\Delta v_2 = \left(-2\frac{\text{m}}{\text{s}^2}\right)(1\text{ s}) = -2\text{ m/s}$
  - ➡ $\Delta v = \Delta v_1 + \Delta v_2 = 4\text{ m/s}$

Equations for Constant Acceleration

- $x = x_0 + v_0 t + \frac{1}{2}at^2$
- $v = v_0 + at$
- $v^2 = v_0^2 + 2a(x - x_0)$

Use these equations to predict the future path and speed of an object under constant acceleration!



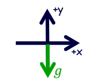
Kinematics: Free Fall—A Special Case

- Free Fall: An object's motion is caused by *gravity alone*
  - $a = g$, the *acceleration of gravity*
  - $g = 9.8\ \text{m/s}^2$
  - The 3 kinematic equations become:
    - » $y = y_0 + v_{0_y}t - 1/2\, gt^2$
    - » $v_y = v_{0_y} - gt$
    - » $v_y{}^2 = v_{0_y}{}^2 - 2g(y - y_0)$

PHYS 101: Lecture 2 — Slide 19 of 27

A Few Facts About *g*

- For Gravity:
  - Acceleration is $g = 9.8\ \text{m/s}^2$ near the surface of the earth.
  - g **always** points downward
  - Position may be positive, zero or negative
  - Velocity may be positive, zero or negative



- To Calculate position or velocity as a function of *time*:
  - Position: $y = y_0 + v_{0y}t - \frac{1}{2}gt^2$
  - Velocity: $v_y = v_{0y} - gt$
- To calculate velocity as a function of *position*:
  - $v_y^2 = v_{0y}^2 - 2g(y - y_0)$

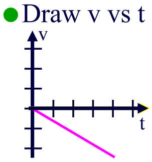
PHYS 101: Lecture 2 — Slide 20 of 27

PHYS 101: Lecture 2 — Slide 21 of 27

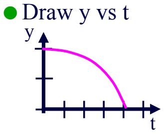
Dropped Ball: Position & acceleration

A ball is dropped from a height of two meters above the ground.

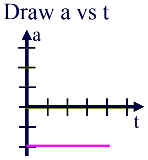
- Draw v vs t



- Draw y vs t



- Draw a vs t



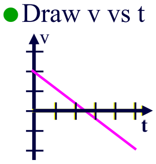
PHYS 101: Lecture 2 — Slide 22 of 27

PHYS 101: Lecture 2 — Slide 23 of 27

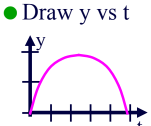
Tossed Ball, x, v, a relationships

A ball is tossed from the ground up a height of two meters above the ground. And falls back down

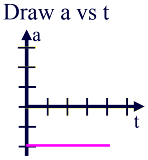
- Draw v vs t



- Draw y vs t



- Draw a vs t



PHYS 101: Lecture 2 — Slide 24 of 27

Summary of Concepts

- Kinematic Quantities:
  - Position & Displacement
  - Velocity & Speed
  - Acceleration
- Free Fall
  - $y = y_0 + v_{0_y} t - 1/2\, gt^2$
  - $v_y = v_{0_y} - gt$
  - $v_y{}^2 = v_{0_y}{}^2 - 2g(y - y_0)$