Physics 1A, Lecture 4: One Dimensional Kinematics and Free Fall

Summer Session 1, 2011

Your textbook should be closed, though you may use any handwritten notes that you have taken. You will use your clicker to answer these questions. If you do not yet have a clicker, please turn in your answers on a sheet of paper. The quiz will commence at 9:33 AM.

Key Questions: (Discuss with neighbors before quiz)

1) What is the SI unit of acceleration?
2) What is the numerical value of g?
3) How does acceleration change during free fall?

Reading Quiz #2-1

- What is the SI unit of acceleration?

A) m/s

B) cm/s

C) ft/s^2

D)(kg m)/s^2

E) None of the above

Reading Quiz #2-2

- What is the numerical value of g in SI units? Choose the closest value:

A) 10

B) 1000

C) 300

D) 30

E) None of the above

Reading Quiz #2-3

- How does acceleration change during free fall?

A) it decreases

B) it stays the same

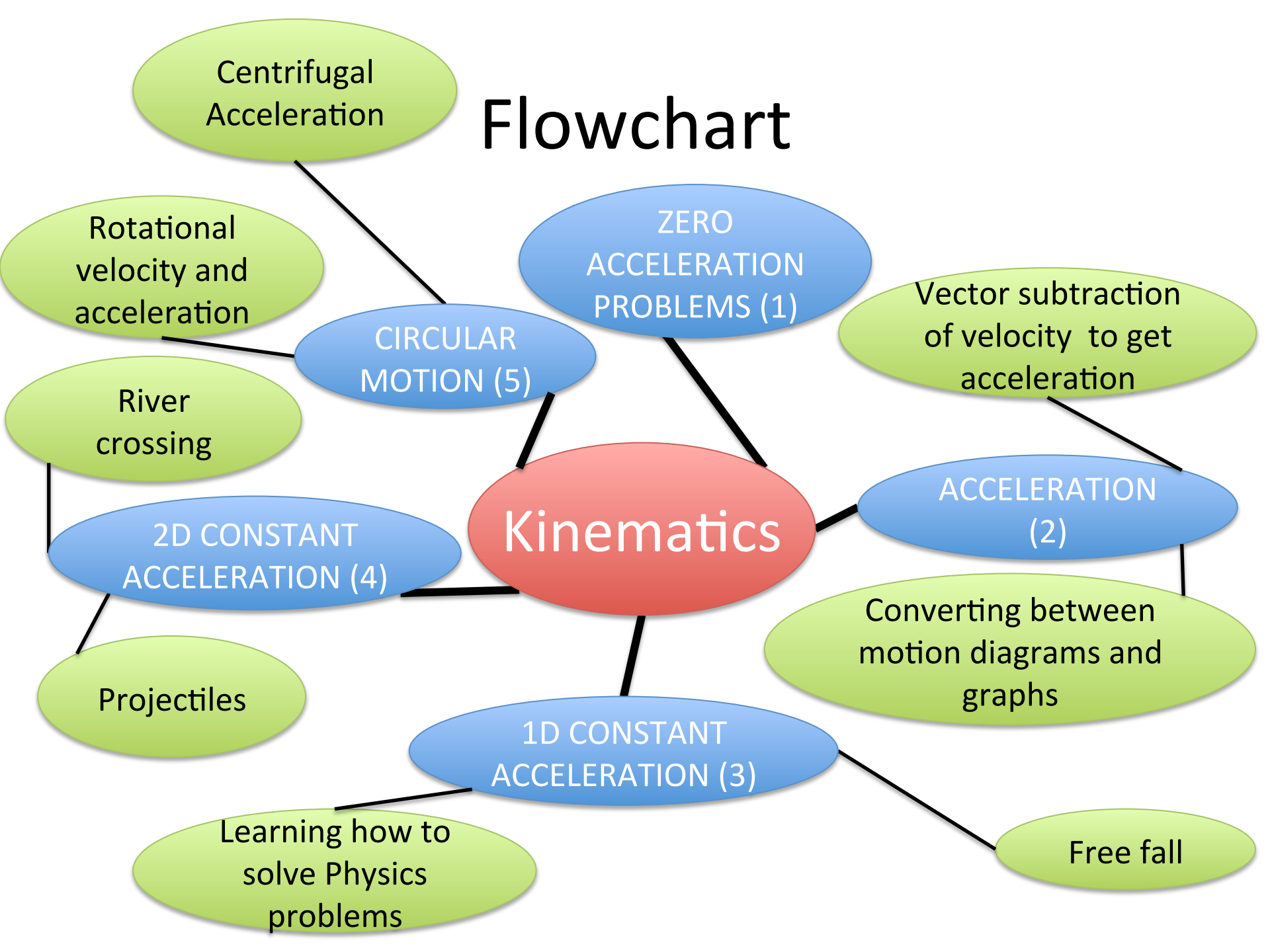
C) it increases

D) it stays the same but only if the object is far away from the earth's surface

E) it depends on if the object was dropped or if it was tossed

Announcements

- Monday is a holiday ☺
- Homework 1 will be returned to you Tuesday
- I will have make up office hours Tuesday 5-6pm
- Homework 2 will be posted by 5pm today
  - due Wednesday (in class or office hours)
- Quiz 1 will be next Thursday


Flowchart
Kinematics
Centrifugal Acceleration
Rotational velocity and acceleration
River crossing
Projectiles
Learning how to solve Physics problems
Free fall
Converting between motion diagrams and graphs
Vector subtraction of velocity to get acceleration
ZERO ACCELERATION PROBLEMS (1)
CIRCULAR MOTION (5)
2D CONSTANT ACCELERATION (4)
1D CONSTANT ACCELERATION (3)
ACCELERATION (2)

Today's poll

What's your major?

A) Biochemistry and Cell Biology

B) Ecology or General Biology

C) Molecular or Microbiology

D) Human Biology, Bioinformatics, or Physiology and Neuroscience

E) Undecided or Other

Kinematics Equations in 1D

- Solve constant acceleration problems:
  - Given initial state predict final state
  - Given finial state predict initial state
  - Given initial or final state, predict acceleration or time interval
- Need some easy easy calculus to derive it…

Initial position x_0

Final position x_f

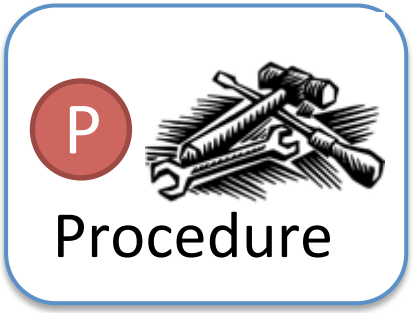
Initial velocity v_0

Final velocity v_f

Constant acceleration a

Time interval t

Derivatives and integrals of polynomial functions



- Derivative of general polynomial:

$$y(x) = A \cdot x^n$$

$$\frac{dy}{dx} = A \cdot n \cdot x^{n-1}$$

- Example:

$$y(x) = 5x^3 + 2x$$

$$\frac{dy}{dx} = 15x^2 + 2$$

- Integral of general polynomial:

$$y(x) = A \cdot x^n$$

$$\int y(x) \cdot dx = \frac{A}{n+1} \cdot x^{n+1}$$

- Example:

$$y(x) = 9x^2 + x$$

$$\int y(x) \cdot dx = 3x^3 + \frac{1}{2}x^2$$

Clicker Question 3-8
Derivatives and integrals

- Which of the following is the derivative of

$$y(x) = \frac{1}{3}x^3 + 2x$$

A) $x^2 + 1$

B) $x^4 + x^2$

C) $x^2 + 2$

D) $x^4 + 2$

E) $\frac{1}{12}x^4 + x^2$

Clicker Question 3-9
Derivatives and integrals

- Which of the following is the integral of

$$y(x) = \frac{1}{3}x^3 + 2x$$

A) $x^2 + 1$

B) $x^4 + x^2$

C) $x^2 + 2$

D) $x^4 + 2$

E) $\frac{1}{12}x^4 + x^2$

$$v(t) = \frac{dx(t)}{dt} = v_0 + at$$

$$a(t) = \frac{dv(t)}{dt} = a$$

C

Concept

Displacement
x(t)

Velocity
v(t)

Constant
Acceleration, a

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

$$v(t) = \int a \cdot dt = v_0 + at$$

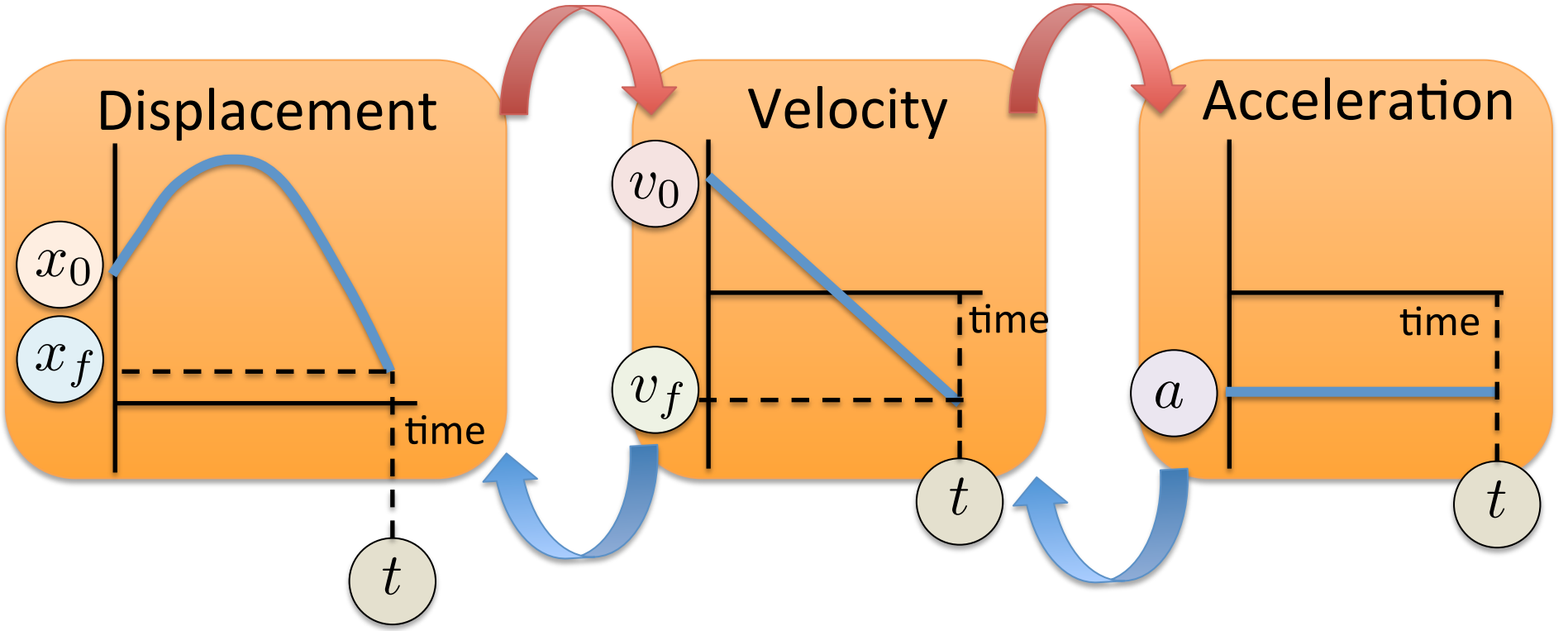
Kinematics equations

C

Concept

$$x_f = x_0 + v_0 t + \frac{1}{2} a t^2$$

$$v_f = v_0 + at$$



Clicker Question 3-10
Kinematics equations

- A car going 50 m/s speeds up at 2 m/s^2 for 5 s. What is the new speed?

$$v_f = v_0 + at$$

A) 20 m/s

B) 40 m/s

C) 55 m/s

D) 60 m/s

E) 100 m/s

Clicker Question 3-11

Kinematics equations

- A car moving in the negative x direction is going 50 m/s. Its initial position is x=10 m. What is the position after 1s?

$$x_f = x_0 + v_0 t + \frac{1}{2} a t^2$$

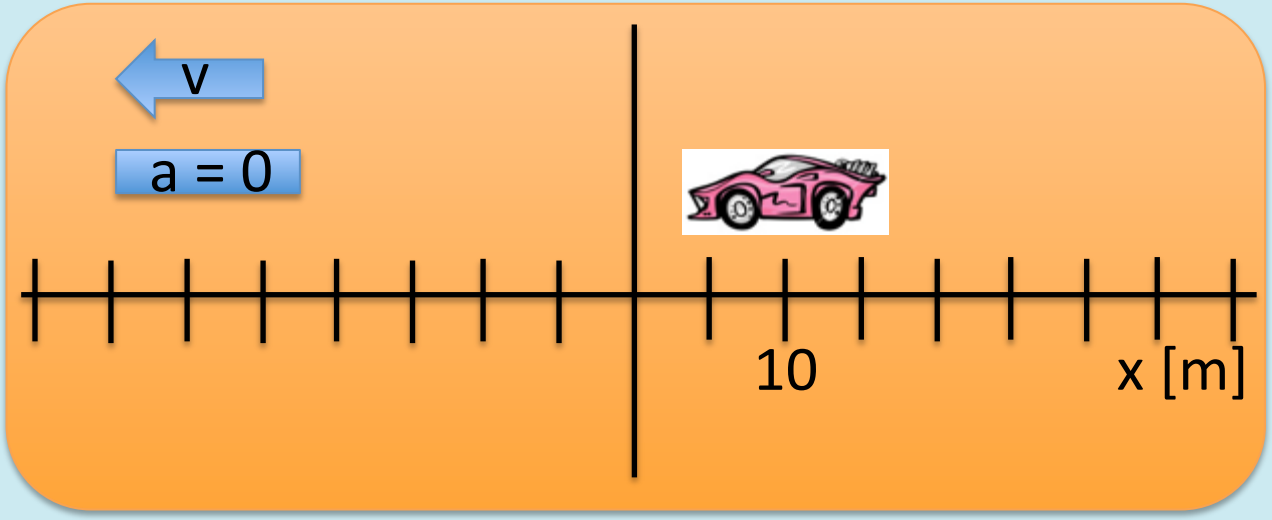
A) - 40 m

B) + 40 m

C) - 60 m

D) + 60 m

E) + 35 m



Clicker Question 3-12
Kinematics equations

- A car moving in the negative x direction is going 50 m/s. It starts speeding up at 2 m/s^2. Its initial position is x=10 m. What is the position after 1s?

$$x_f = x_0 + v_0 t + \frac{1}{2} a t^2$$

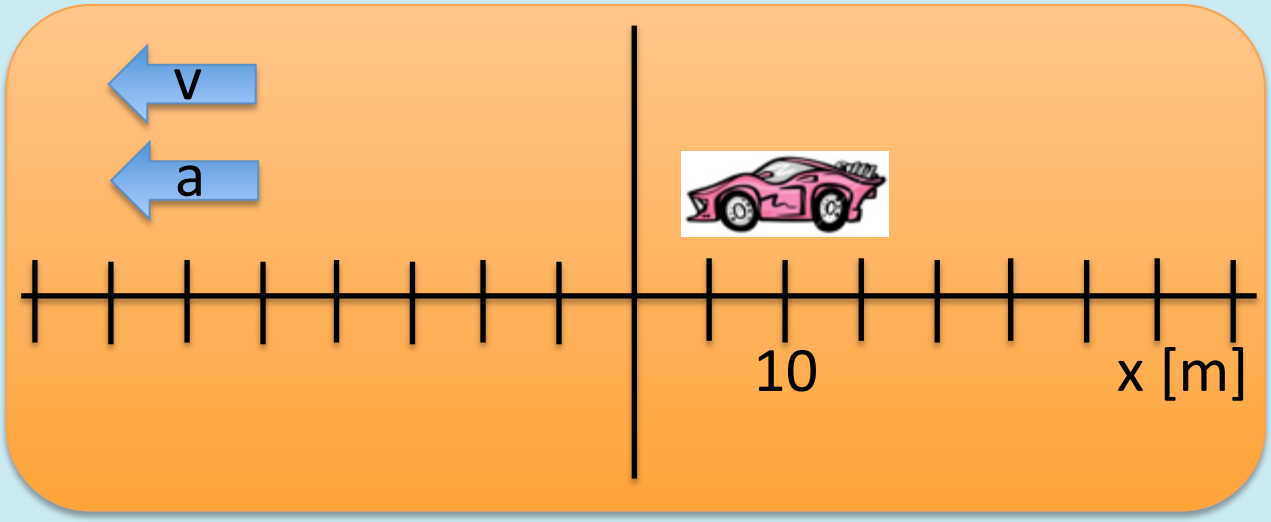
A) + 39

B) - 39

C) - 41

D) + 59

E) +61



Clicker Question 3-13
Kinematics equations

- A car moving in the negative x direction is going 10 m/s. It starts slowing down at 1 m/s^2. Its initial position is x=-5 m. What is the position after 2s?

$$x_f = x_0 + v_0 t + \frac{1}{2} a t^2$$

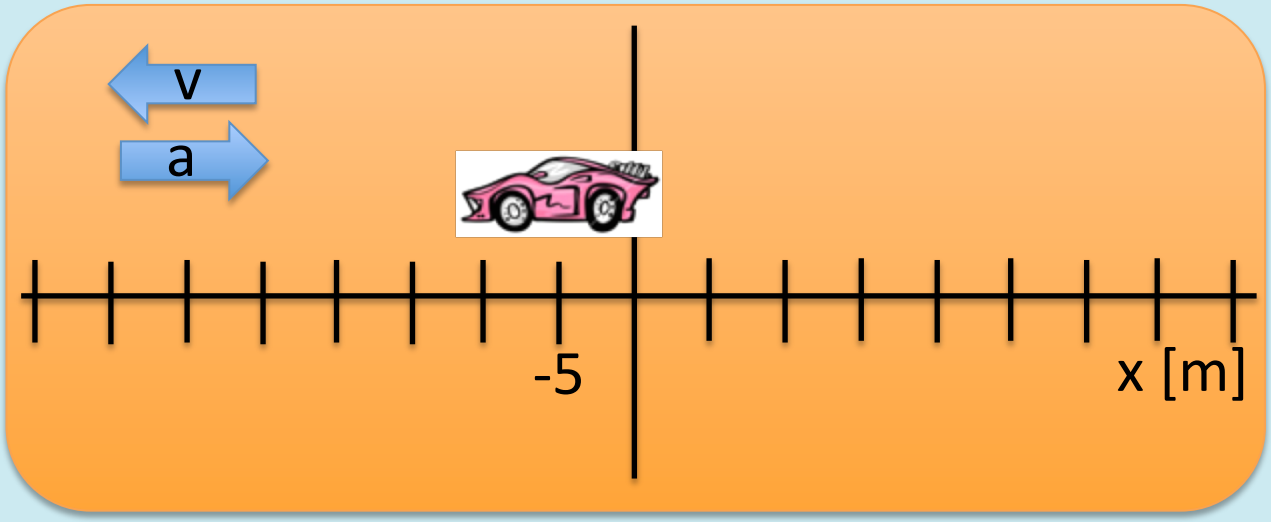
A) - 27

B) + 27

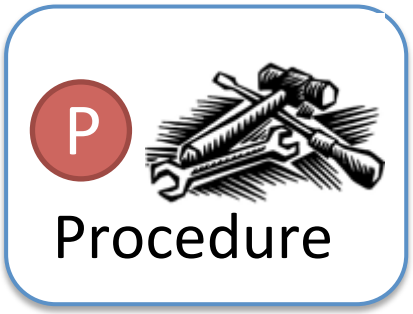
C) - 25

D) + 25

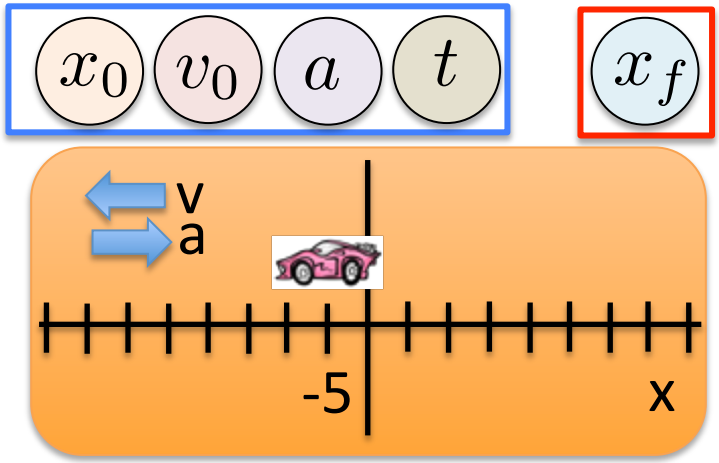
E) - 23



How to solve physics problems



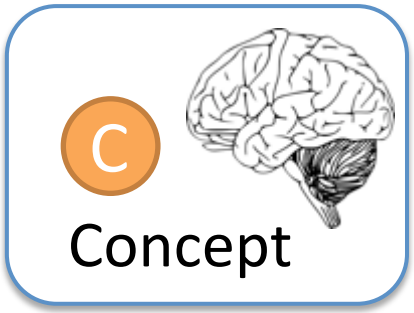
1) Collect all the knowns and unknowns
2) Draw a picture with a coordinate system
3) Find the appropriate equations
   - Make sure you have enough equations!
4) Plug in the known parameters and solve



$$x_f = x_0 + v_0 t + \frac{1}{2} a t^2$$

$$x_f = (-5m) + (-10\frac{m}{s})(2s) + \frac{1}{2}(1\frac{m}{s^2})(2s)^2$$
$$= -23m$$

2 more Kinematics equations



- Sometimes knowns and unknowns require that you use different equations.
- Use this when you're not interested in a :

$$x_f = x_0 + \langle v \rangle t$$
$$= x_0 + \frac{1}{2}(v_f + v_0)t$$

- Or this when you're not interested in t :

$$v_f^2 = v_0^2 + 2a \cdot \Delta x$$

Clicker Question 3-14

Kinematics equations

A car starts at x=10 m at a velocity of 2 m/s to the right. It slows down with a constant acceleration for 5 seconds and comes to a stop. Where does it end up?

$$x_f = x_0 + \frac{1}{2}(v_f + v_0)t$$

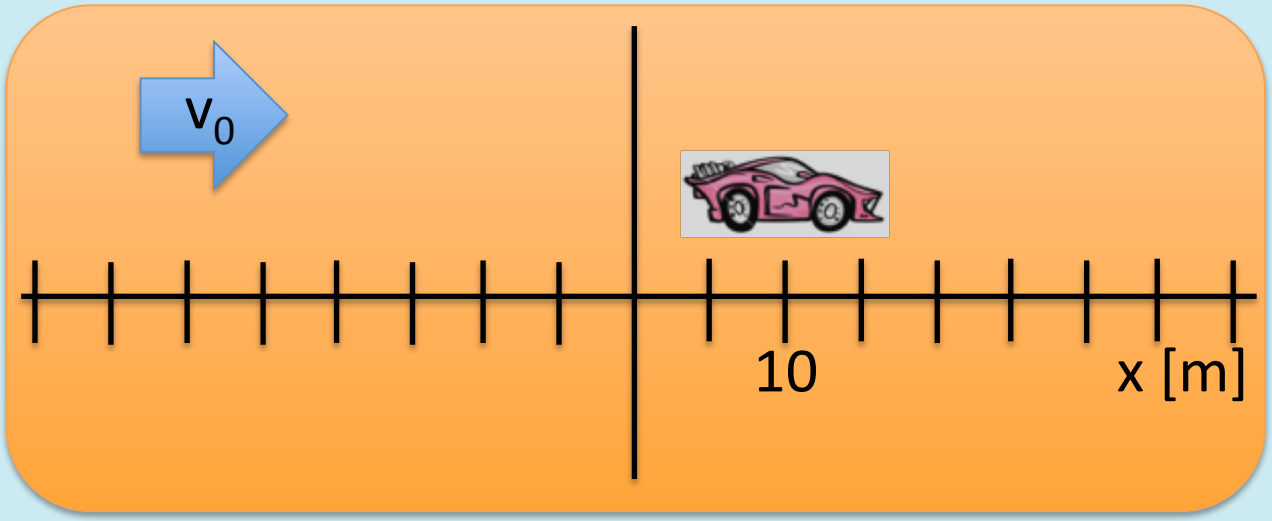
A) + 12 m

B) + 15 m

C) + 20 m

D) + 30 m

E) + 40 m



Clicker Question 3-15

Kinematics equations

A car starts at x=10 m at a velocity of 2 m/s to the right. It slows down with a constant acceleration of 1 m/s^2 and comes to a stop. Where does it end up?

$$v_f^2 = v_0^2 + 2a \cdot \Delta x$$

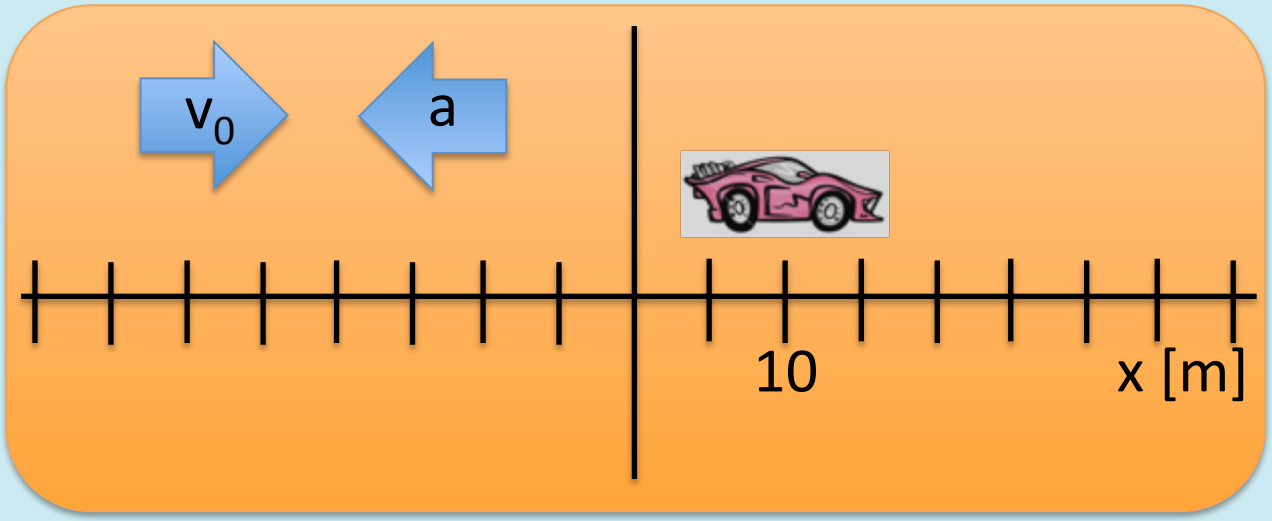
A) + 12 m

B) + 13 m

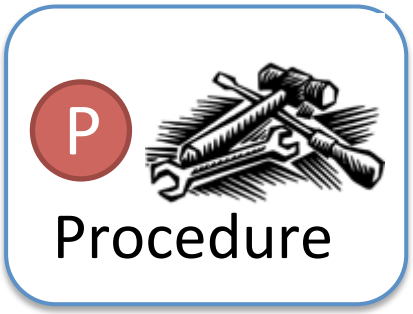
C) + 15 m

D) + 20 m

E) + 25m



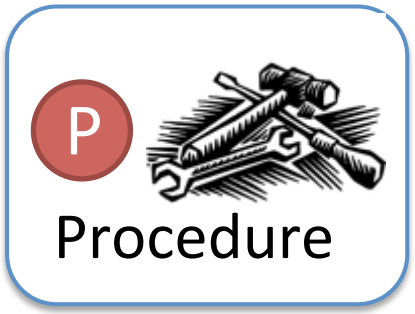
How to choose which kinematics equation to use?



	Actors:	Missing:
$x_f = x_0 + v_0 t + \frac{1}{2} a t^2$	x_f x_0 v_0 t a	v_f
$v_f = v_0 + at$	v_0 v_f t a	x_f x_0
$x_f = x_0 + \frac{1}{2}(v_f + v_0)t$	x_f x_0 v_0 v_f t	a
$v_f^2 = v_0^2 + 2a(x_f - x_0)$	v_f v_0 a x_f x_0	t

1) Compile list of *Knowns* from description of problem (watch out for things that are zero but are not explicitly stated):

2) Identify the *Desired* variable (Lead Actor):



Knowns: v_f v_0 a x_0 Desired: x_f

	Actors:	Missing:
$x_f = x_0 + v_0 t + \frac{1}{2} a t^2$	x_f x_0 v_0 t a	v_f
$v_f = v_0 + at$	v_0 v_f t a	x_f x_0
$x_f = x_0 + \frac{1}{2}(v_f + v_0)t$	x_f x_0 v_0 v_f t	a
$v_f^2 = v_0^2 + 2a(x_f - x_0)$	v_f v_0 a x_f x_0	t

3) Cross out the *Knowns* to look at *Unknowns*

4) Try to minimize the amount of work you have to do

Knowns: v_f v_0 a x_0 Desired: x_f

P 

Procedure

	Actors:	Missing:
$x_f = x_0 + v_0 t + \frac{1}{2} a t^2$	x_f ~~x_0~~ ~~v_0~~ t ~~a~~	v_f
$v_f = v_0 + at$	~~v_0~~ ~~v_f~~ t ~~a~~	x_f x_0
$x_f = x_0 + \frac{1}{2}(v_f + v_0)t$	x_f ~~x_0~~ ~~v_0~~ ~~v_f~~ t	a
$v_f^2 = v_0^2 + 2a(x_f - x_0)$	~~v_f~~ ~~v_0~~ ~~a~~ x_f ~~x_0~~	t

Alternative variables

- Sometimes you'll see alternative notations for the four equations:
  - Displacement:

Δx $\Delta x = x_f - x_0$

  - Change in velocity:

Δv $\Delta v = v_f - v_0$

  - Average velocity:

$\bar{v}$ $\bar{v} = \frac{1}{2}(v_f + v_0)$

$$\Delta x = v_0 t + \frac{1}{2} a t^2$$

$$\Delta v = at$$

$$\Delta x = \bar{v} t$$

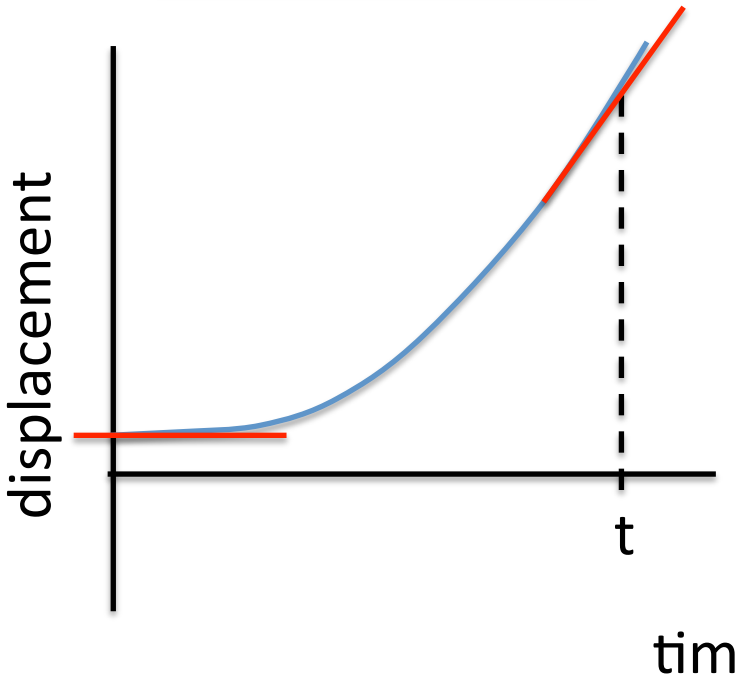
$$v^2 = v_0^2 + 2a\Delta x$$

x_0 x_f v_0 v_f a t

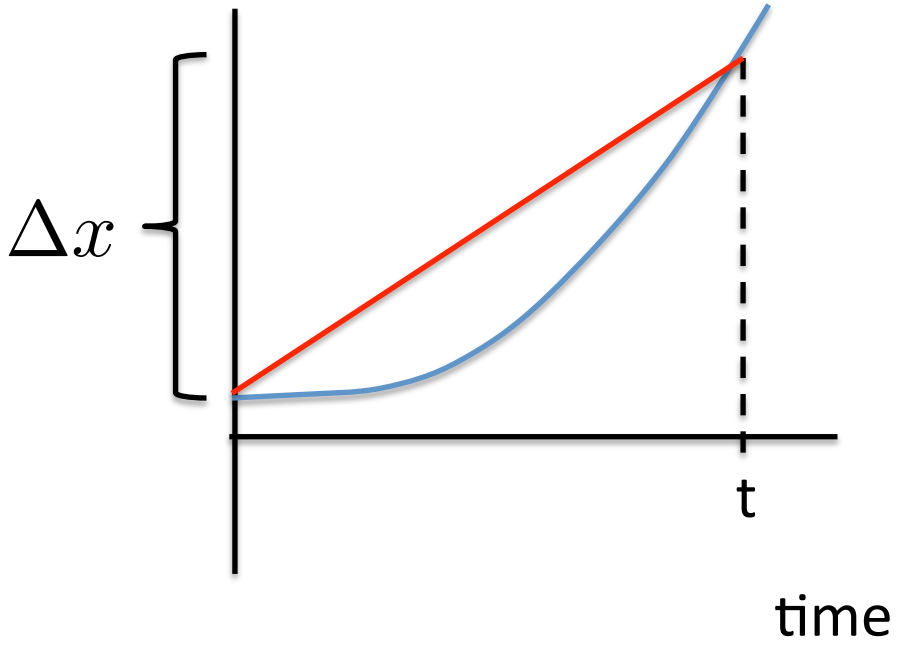
Average velocity

$\bar{v}$

$$\bar{v} = \frac{1}{2}(v_f + v_0)$$



$$\bar{v} = \frac{\Delta x}{t}$$

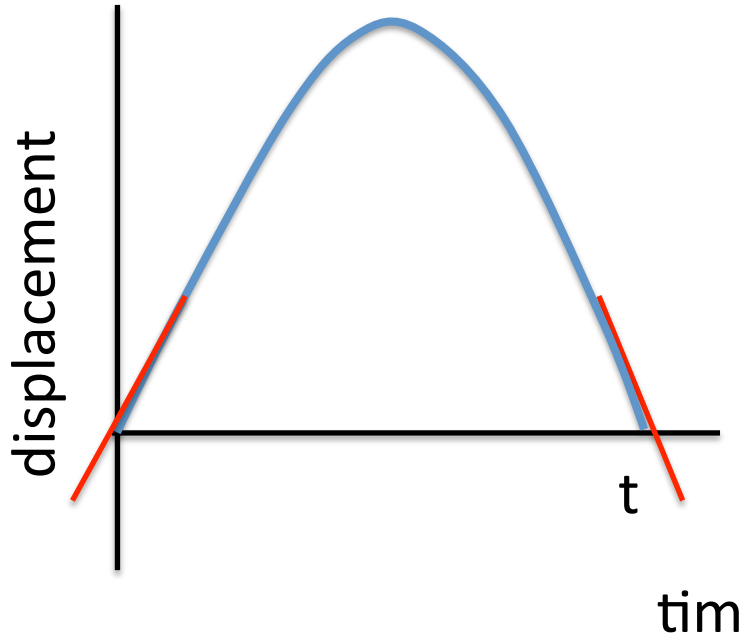


Average velocity

$\bar{v}$

$$\bar{v} = \frac{1}{2}(v_f + v_0)$$

$$\bar{v} = \frac{\Delta x}{t}$$



- acceleration held constant
- return to starting position

Clicker Question 3-10
Free Fall Concepts

You toss a ball straight up into the air. Just after leaving you hand, what is its acceleration? (g = 9.8 m/s^2)

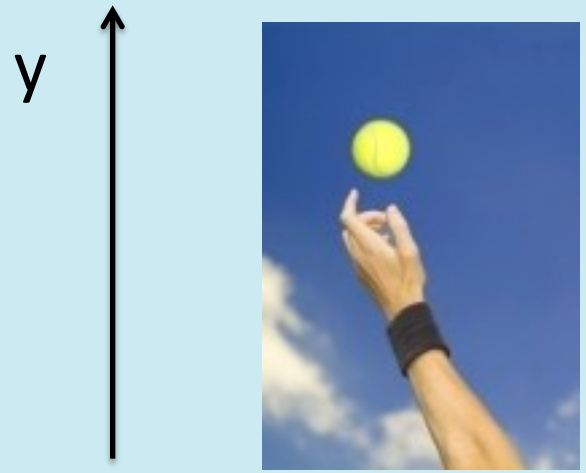
A) g

B) -g

C) 0

D) < g

E) > g



Clicker Question 3-10
Free Fall Concepts

You toss a ball straight up into the air. At the very top of its trajectory what is its acceleration? (g = 9.8 m/s^2)

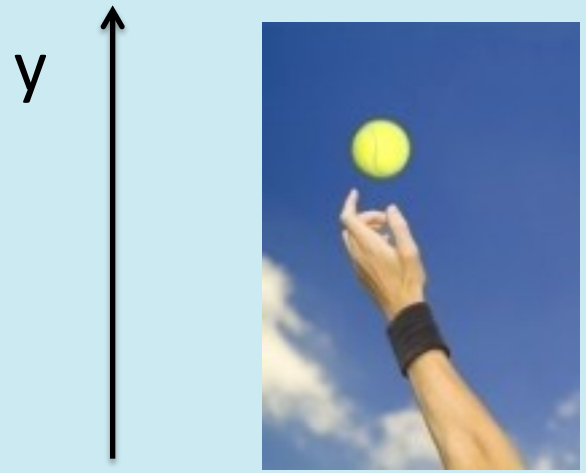
A) g

B) -g

C) 0

D) < g

E) > g



Clicker Question 3-10
Free Fall Concepts

You toss a ball straight up into the air. Just before hitting the ground, what is its acceleration? (g = 9.8 m/s^2)

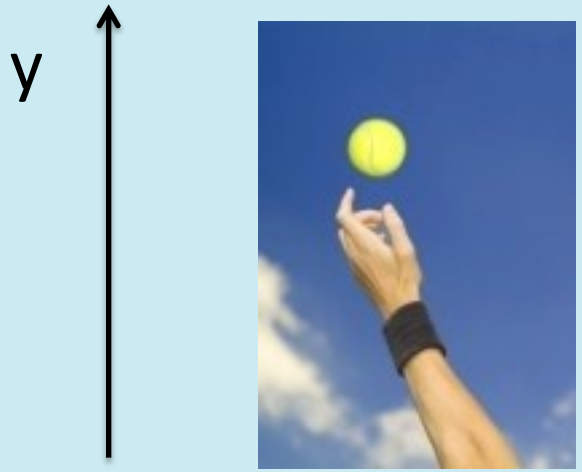
A) g

B) -g

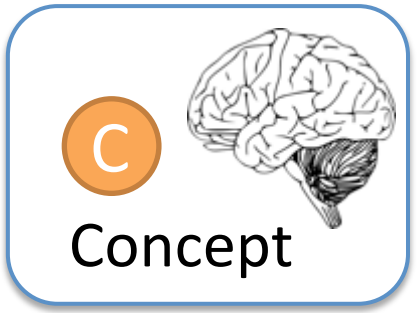
C) 0

D) < g

E) > g



Force → acceleration



- Huge topic for next week:
  - Only way to have acceleration of an object is when there is a force acting on it
- Three things that cause acceleration:
  - Gravity (always constant in magnitude and direction!)
  - Gas or brake pedal (though cars can also coast)
  - Person in contact with object applying a force
- Things that *do not* cause acceleration:
  - Throwing stuff (can only cause velocity)

New actors, same roles

$$h = h_0 + v_{0y}t + \frac{1}{2}a_y t^2$$

$$v_y = v_{0y} + a_y t$$

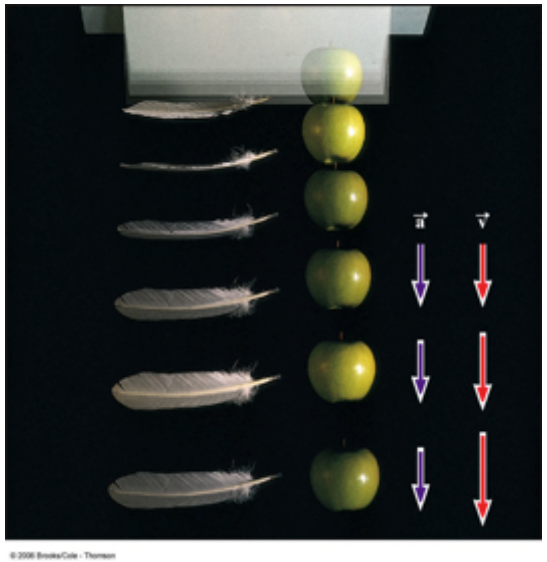
$$h = h_0 + \frac{1}{2}(v_{0y} + v_y)t$$

$$v_y^2 = v_0^2 + 2a_y(h - h_0)$$

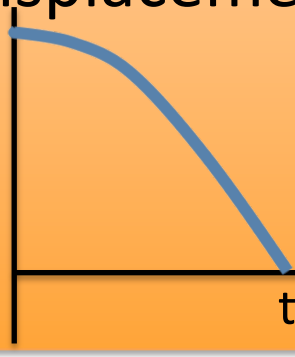
h_0 h

v_{0y} v_y

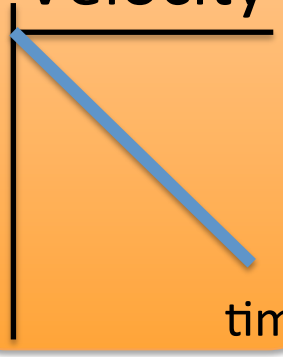
a_y t



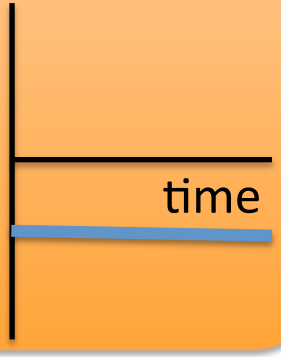
Displacement



Velocity



Acceleration



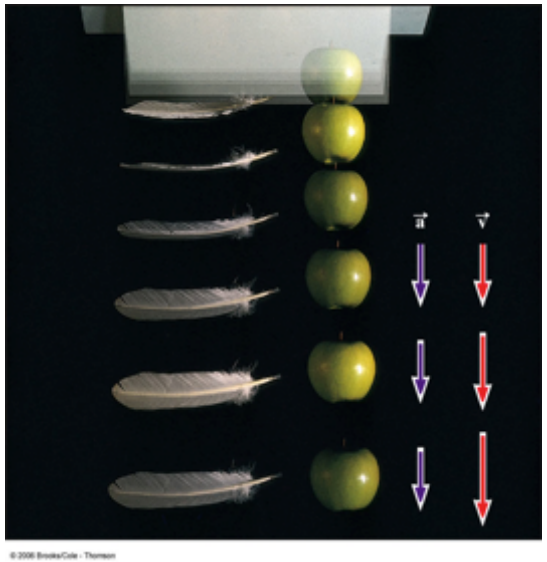
$$a_y = -g$$

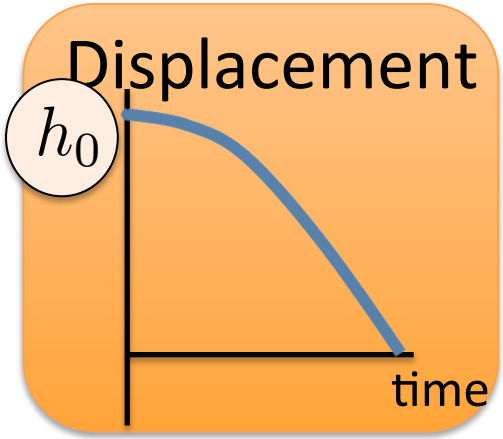
Dropping from rest

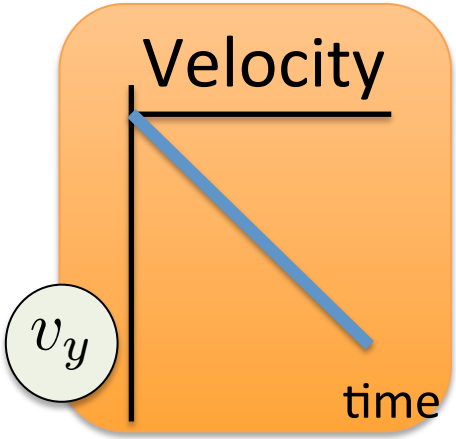
$$h = h_0 + v_{0y}t + \frac{1}{2}a_y t^2$$

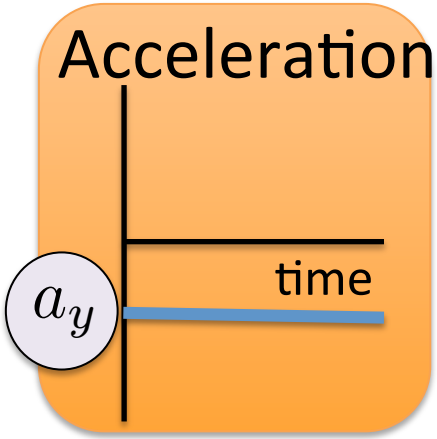
$$h_0 = \frac{1}{2}gt^2$$

h_0 h v_{0y} v_y a_y t









$$a_y = -g$$

Homework

- No class Monday, Monday's office hours moved to Tuesday 5-6pm.
- Quiz #1 will be next Thursday covering Ch 1-3
  - This covers the Math review and Kinematics
- Get ready for Tuesday's reading quiz
  - See assignment and questions posted on website
- Start on Homework #2, which is due next Wednesday
  - Download this from the website after 5pm tonight