Lecture 05:

Recap Chapter 2 "Motion in 1 dimension"

5th lecture, 2nd chapter, 1st dimension

Erik Lascaris

Announcements

- ***Today (and tomorrow):***

  Lab #1!

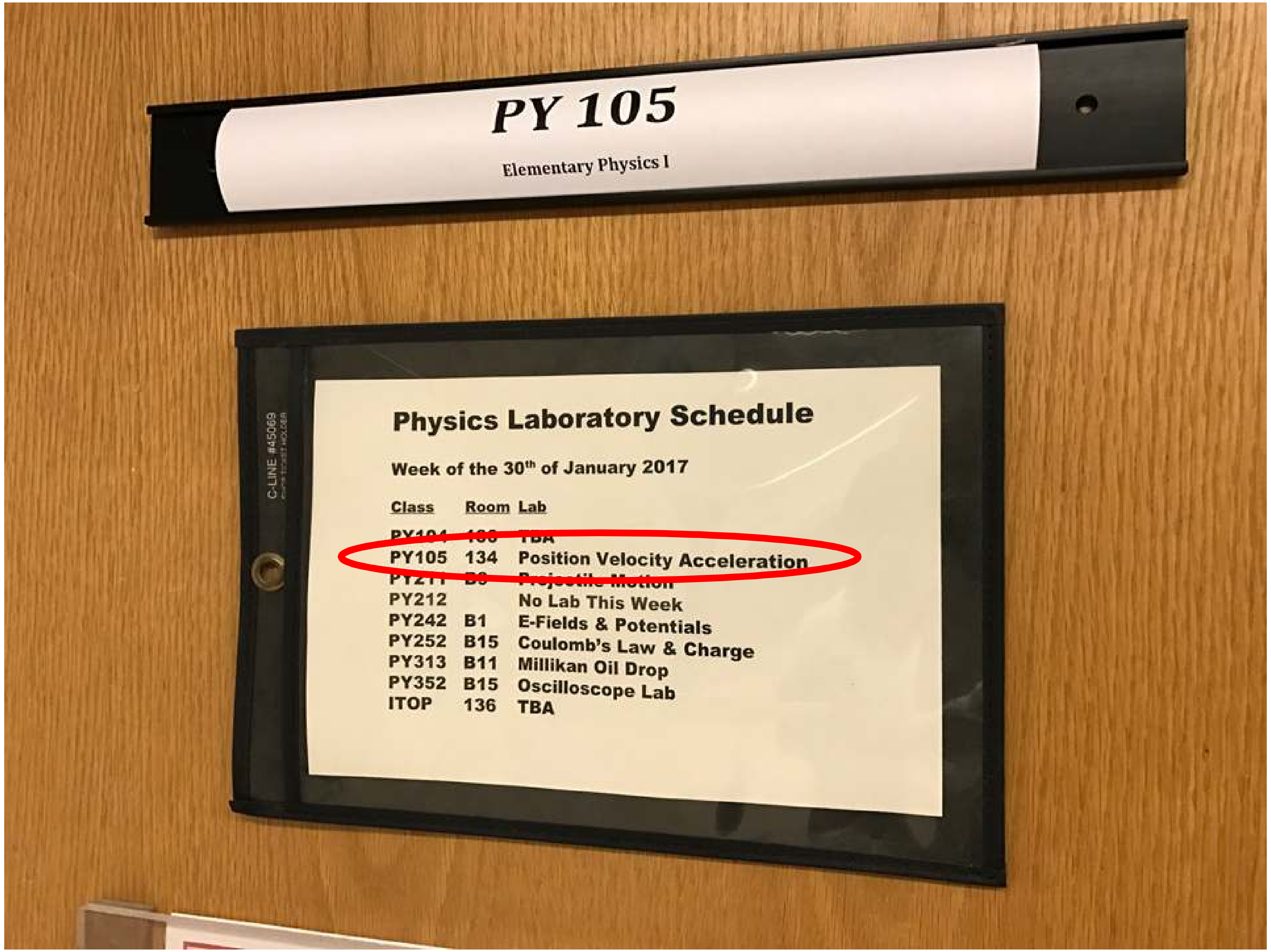
- ***Where's the lab?***

  SCI-134

- ***When?***

  Check StudentLink

  (first one is tonight 6:30pm)



Announcements

- Homework 2: due tomorrow!
  - Office hours today + tomorrow, 4-6pm.
  - Piazza is full of smart people that can answer your questions!

- Office hours (me): today & tomorrow (Mon & Tue) 4-6pm in SCI-121

- Office hours (TFs & LAs): tell them what times you'd prefer

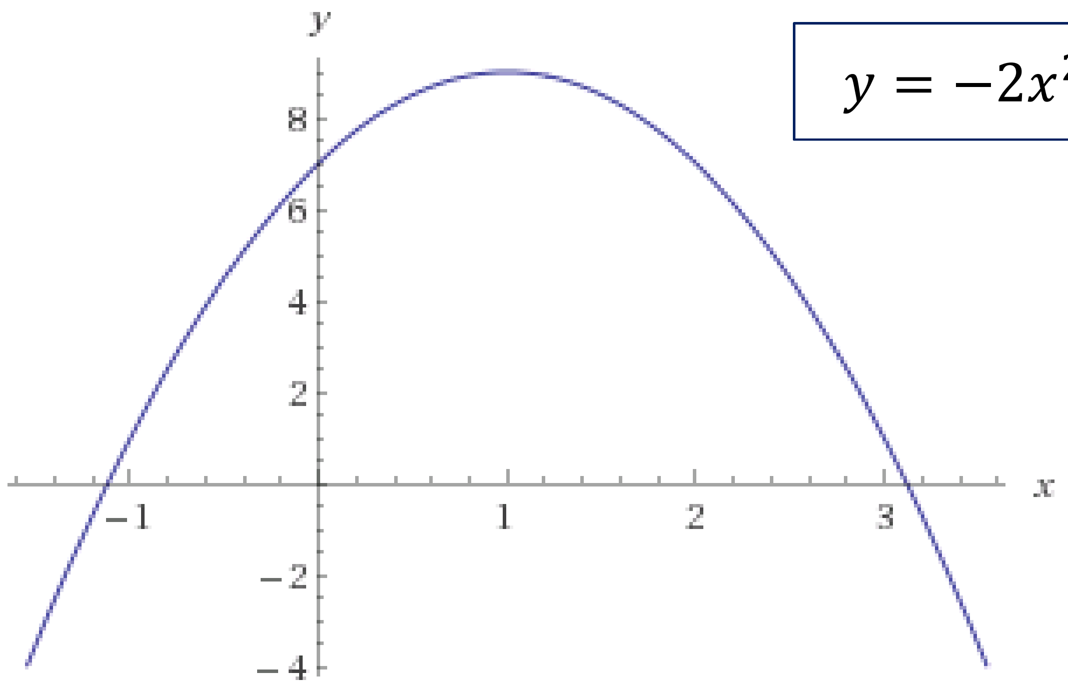
Plan for today!

- Do some example problems

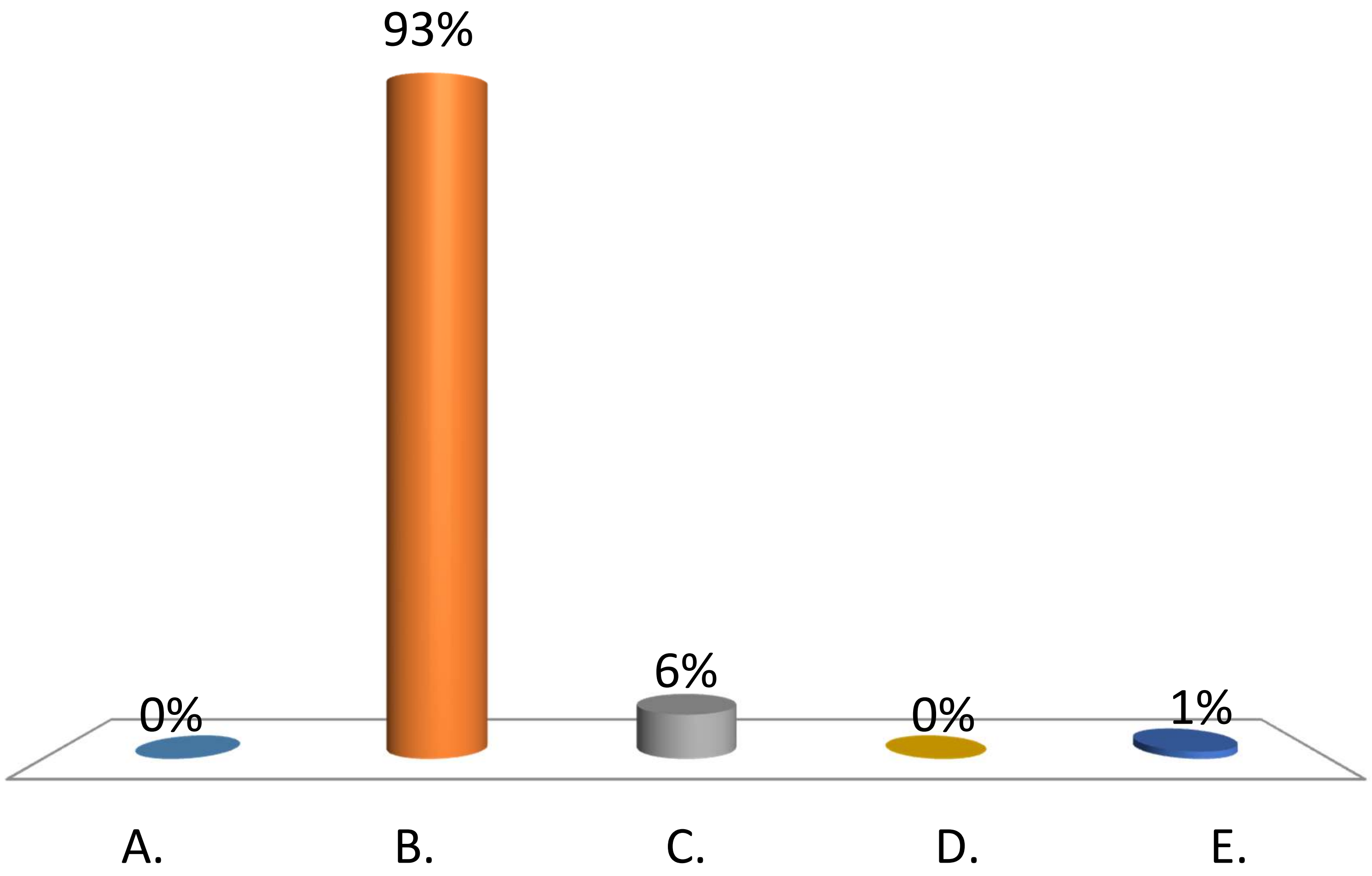
- Give you some hints for the homework
  - Useful equation for HW 2, problem 10

What is the name of this curve?

A. Straight line
B. Parabola
C. Hyperbola
D. Cubic
E. None of the above



$$y = -2x^2 + 4x + 7$$



What is the name of this curve?

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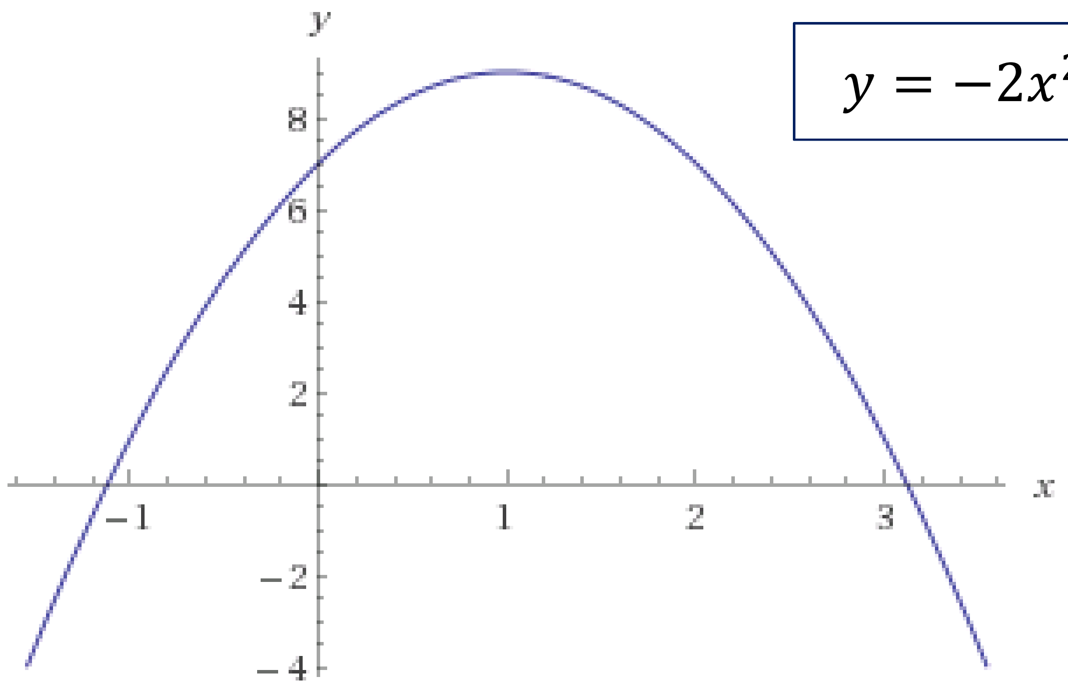
If you make a graph of a quadratic equation,

$$y = ax^2 + bx + c$$

then the shape of that curve is a parabola.



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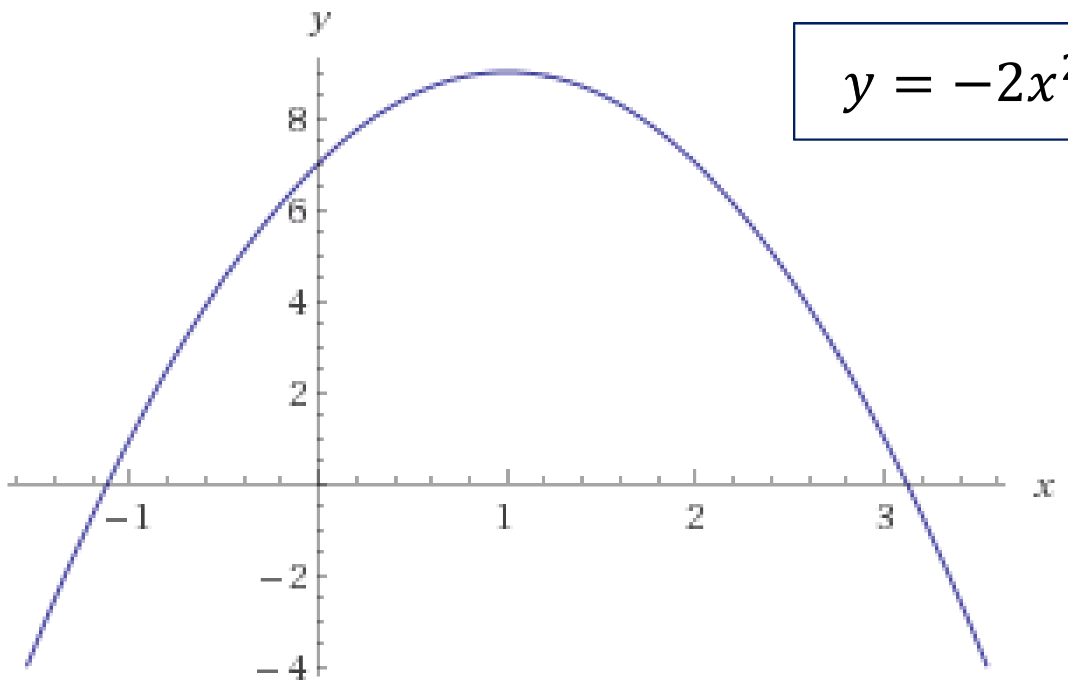

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The maximum (or minimum) of a parabola is at:

$$x_{\max} = -\frac{b}{2a}$$

(easy to show using derivatives – or just memorize)

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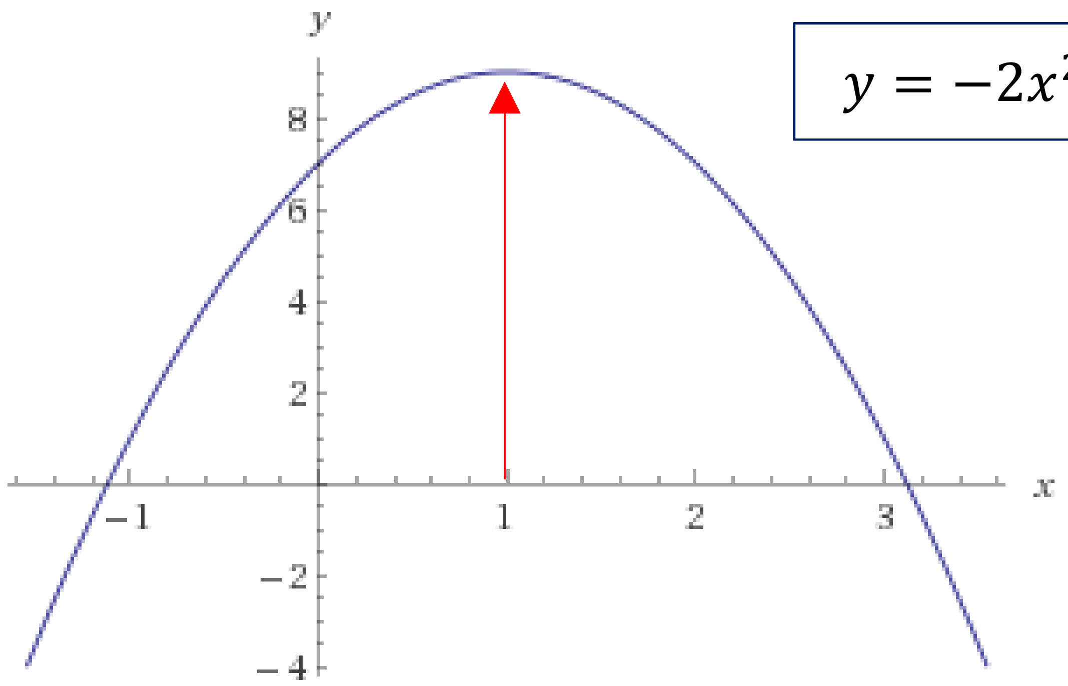

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In this case:

$$x_{\max} = -\frac{4}{2(-2)} = 1$$

What is the name of this curve?

A. Straight line

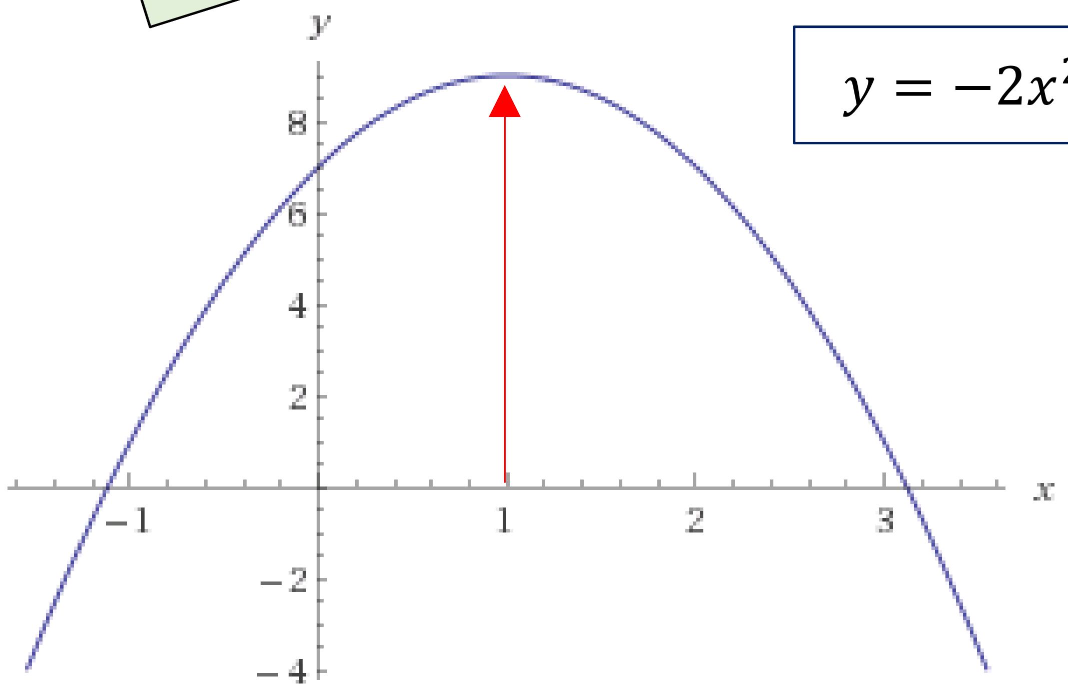
B. **Parabola**

C. Hyperbola

D.

E. ... above

Quadratic equations and parabolas occur frequently in problems with kinematics



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The kinematic equations

Assuming *constant acceleration* a:

- Position x of object at time t: $x = x_i + v_i t + \frac{1}{2} a t^2$

- Speed v of object at time t: $v = v_i + at$

- Also useful, when you don't care about time t: $v^2 = v_i^2 + 2a(x - x_i)$

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Combine equations,
eliminate t,
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Let's consider some examples!

Most awesome example of kinematics

Lamborghini Diablo

Capable of accelerating
from 0-60 mph in 5.4 seconds!

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What is its acceleration in m/s^2?

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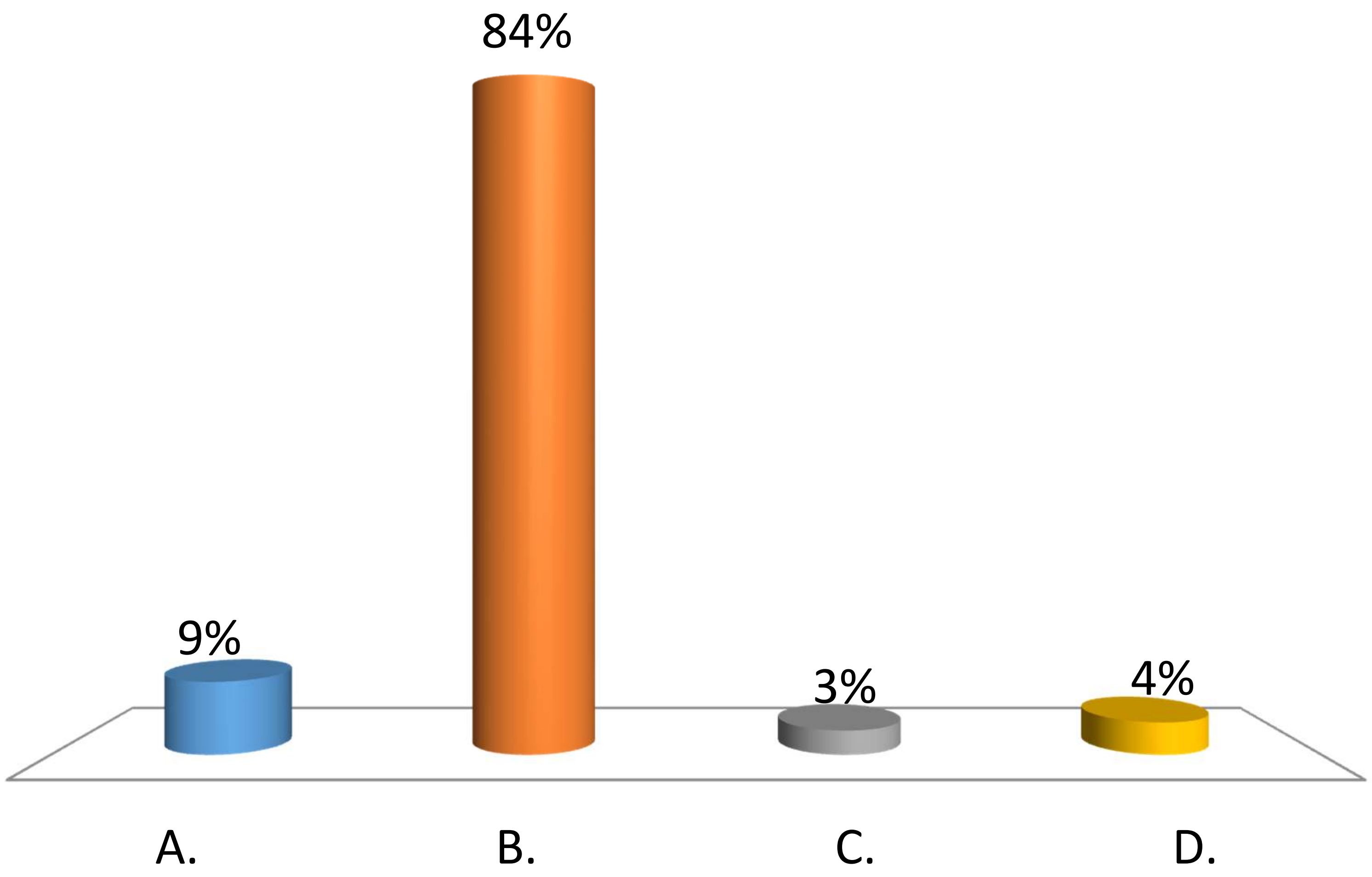

Diablo does 0-60 mph in 5.4 sec. What is its acceleration in m/s^2?

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But why?

Diablo does 0-60 mph in 5.4 sec.
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How fast does a Lamborghini Diablo accelerate?

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How to solve a physics problem:

1. Make a list of things given to us, and what we are looking for. (And convert to SI units!)
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3. Solve!

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- Looking for: a

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Convert mph to m/s:

$$v = \frac{60 \text{ miles}}{\text{hour}}$$

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- Initial speed: $v_i = 0$
- Speed at time $t = 5.4$ s: $v = 60$ mph $=$ 26.822 m/s
- Looking for: a

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$$v = v_i + at$$

$$26.822 = 0 + a(5.4)$$

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$$v = v_i + at$$

$$26.822 = 0 + a(5.4)$$

$$a = 4.97 \text{ m/s}^2$$

Maybe that problem was too simple,
but it gives you an idea of what the best approach is.

Example problem #2a

You drop a coin in a wishing well. After 3 seconds you hear a "plop". How deep is the well?

Example problem #2a

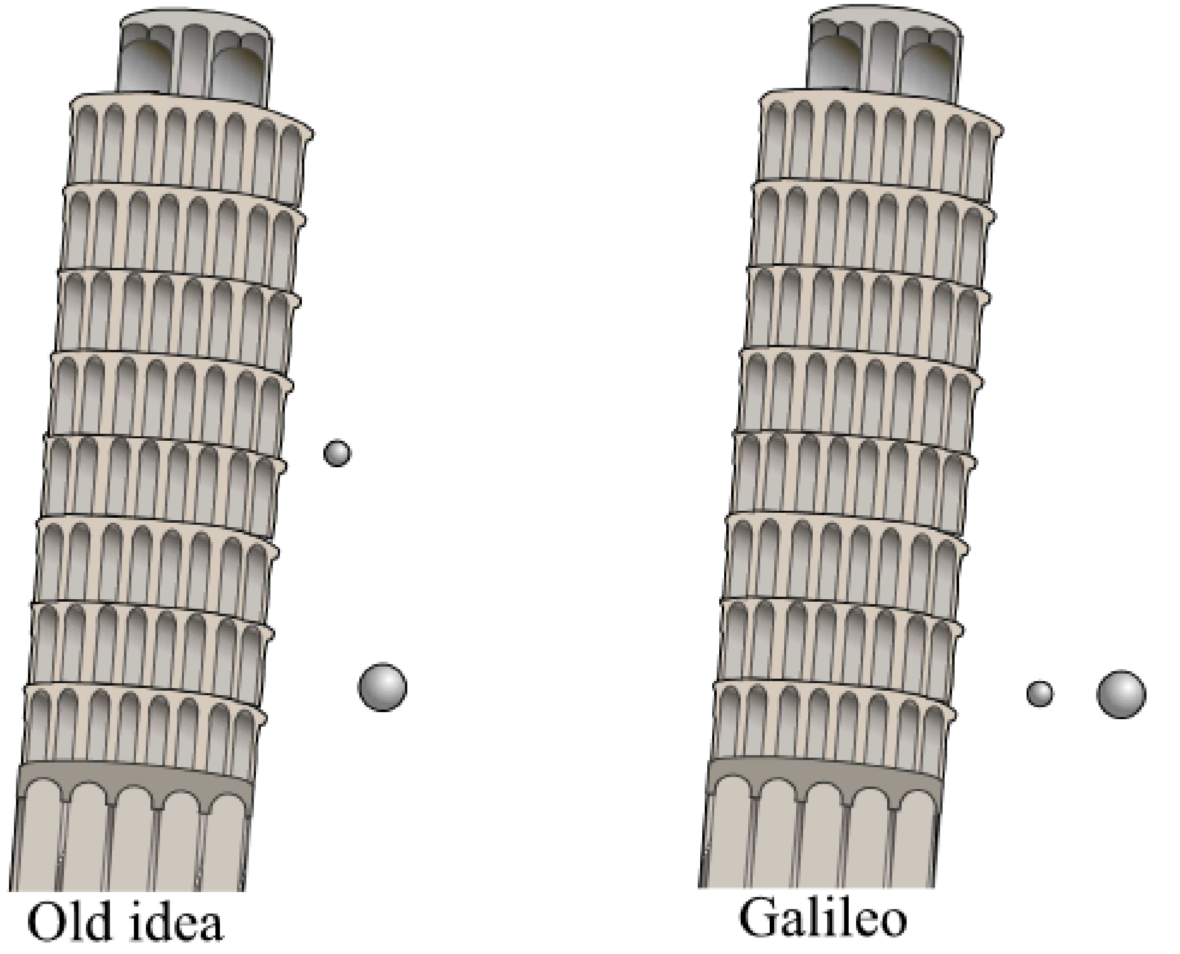
You drop a coin in a wishing well. After 3 seconds you hear a "plop". How deep is the well?

NOTICE: you do not need to know how heavy the coin is!

Any object (regardless of its mass)
falls with the same acceleration to the ground*

* if we'd ignore air resistance

Galileo's Leaning Tower of Pisa experiment



Didn't really happen,
but still makes a great story.

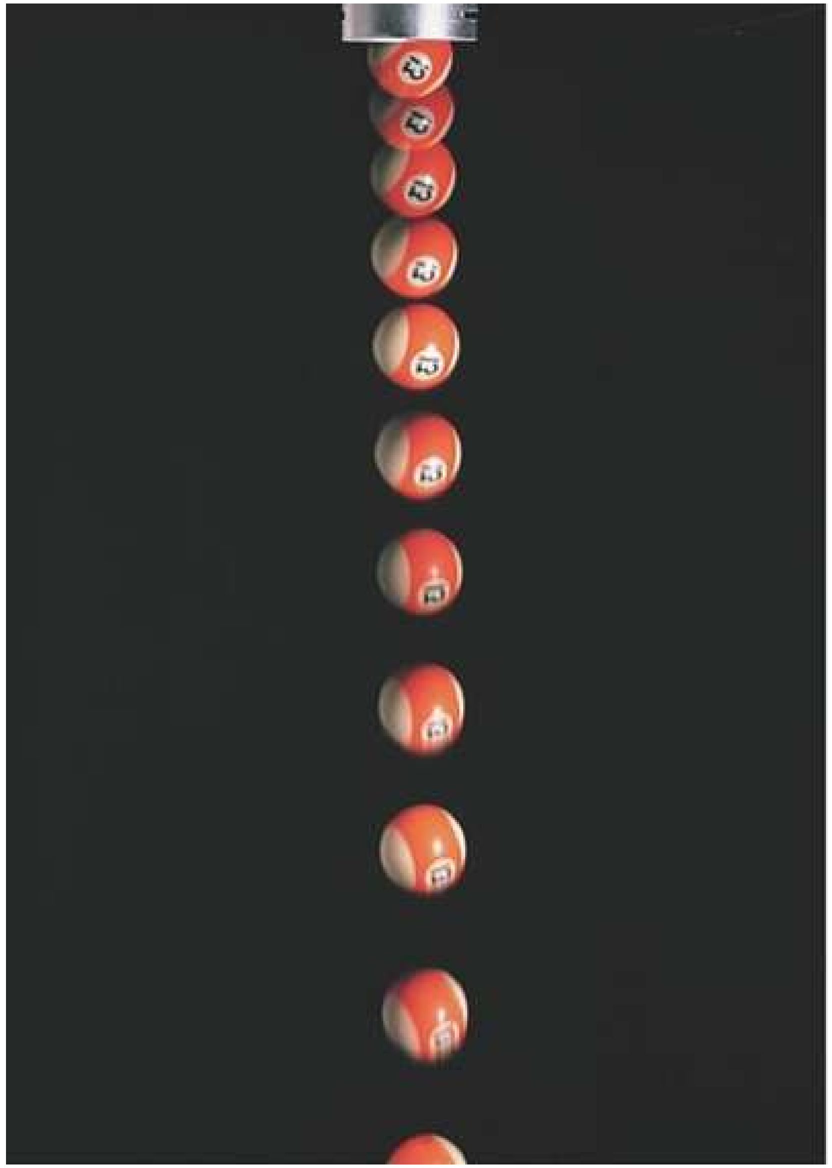
Gravity!

- When an object falls, it always accelerates with a constant acceleration of

$$a_{\text{gravity}} = 9.81\ \text{m/s}^2$$

- We will use this number a lot, so we give it a special symbol:

$$g = 9.81\ \text{m/s}^2$$



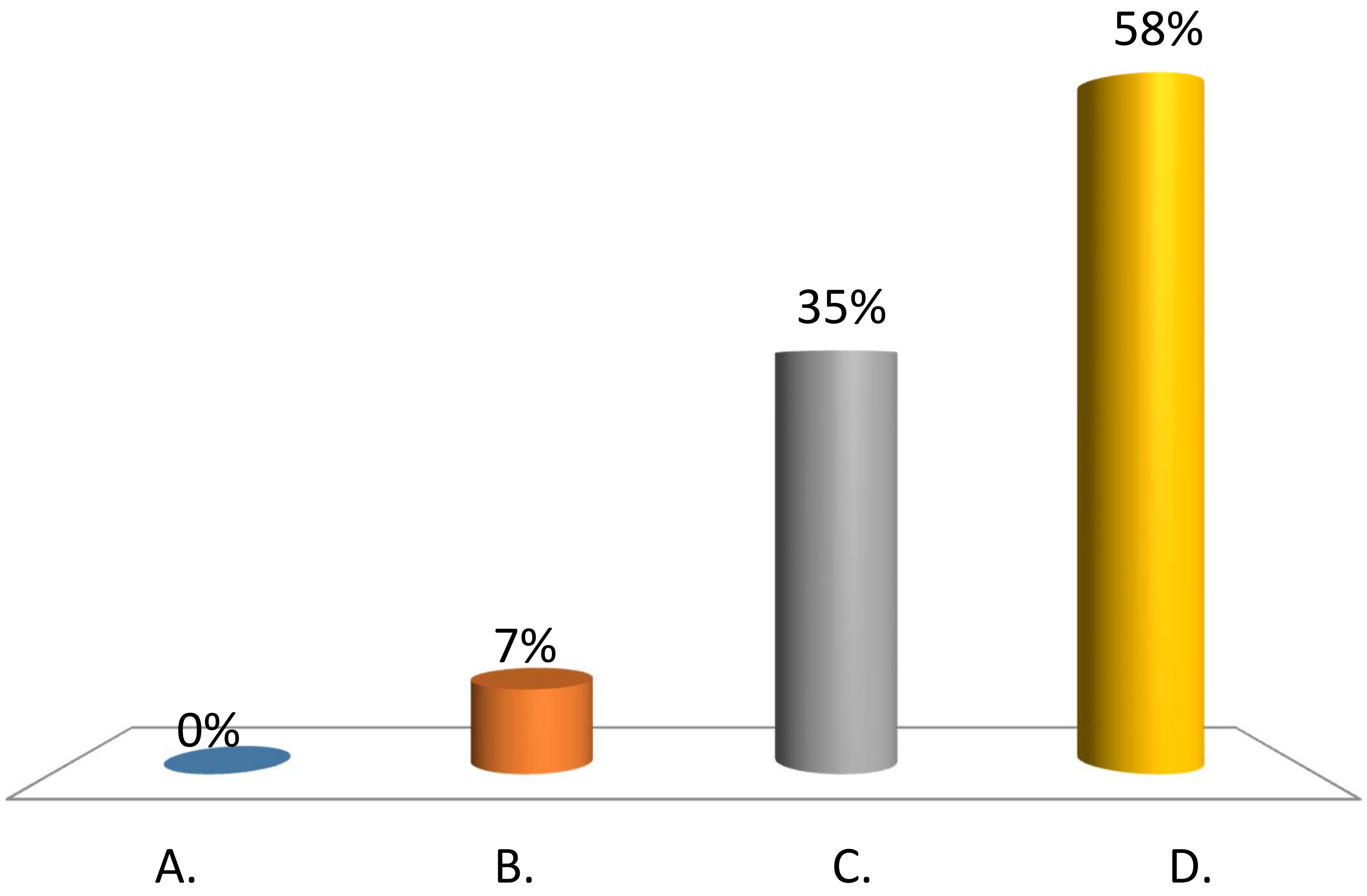
Which object hits the bottom first?

A. Feather first

B. Coin first

C. Both at the same time

D. It depends



Which object hits the bottom first?

A. Feather first
B. Coin first <-- if there's air
C. Both at the same time <-- without air!
D. It depends

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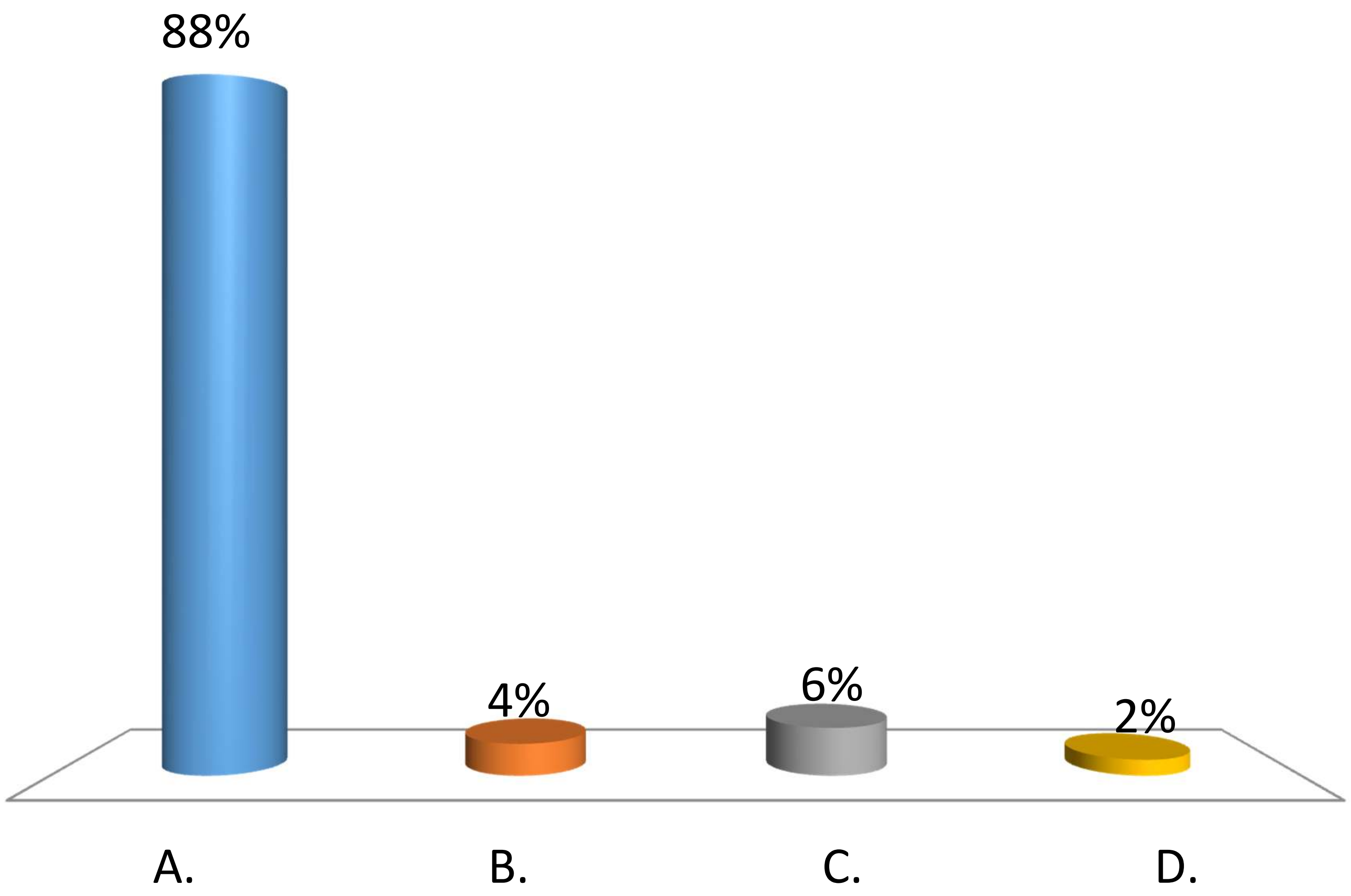

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List of things given / to find:

- You "drop" the coin (not thrown): $v_i = 0$
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- We are free to choose $y_i = 0$
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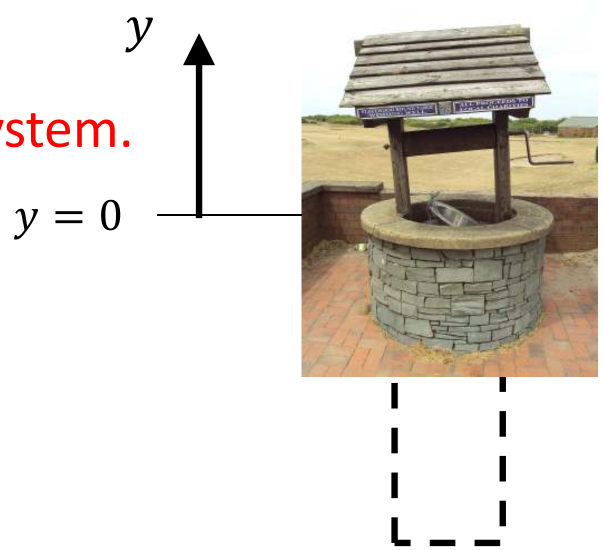
Choose a coordinate system.



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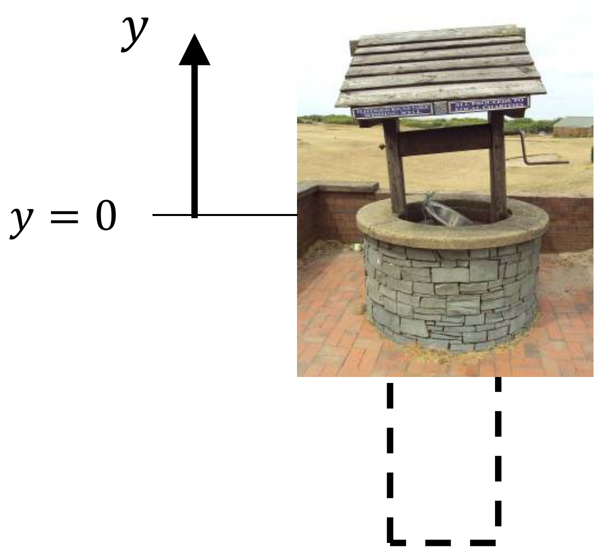

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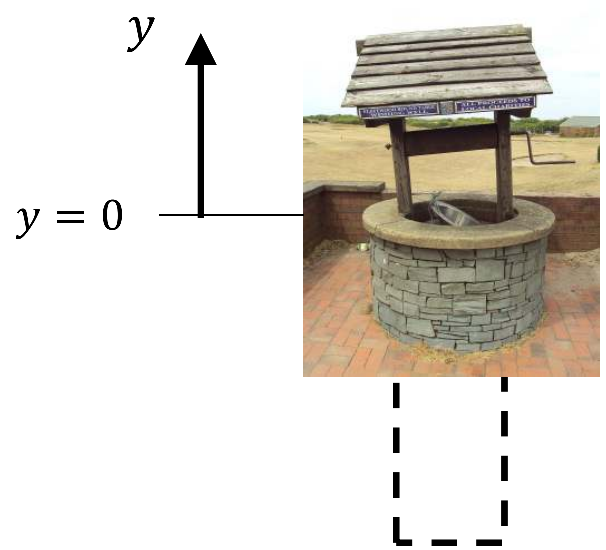

$$y = y_i + v_i t + \frac{1}{2}at^2$$

$$= 0 + (0)(3) + \frac{1}{2}(-9.81)(3)^2$$

Which equation should we use?

You drop a coin in a wishing well. After 3 seconds you hear a "plop". How deep is the well?

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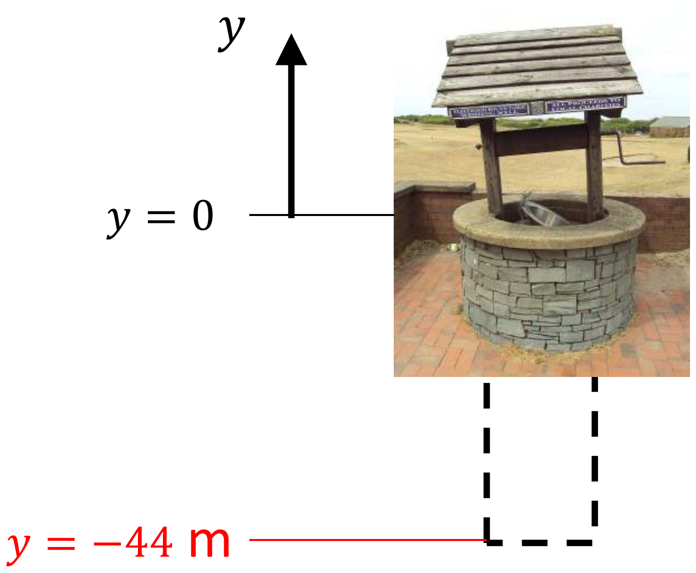

$$y = y_i + v_i t + \frac{1}{2}at^2$$

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$$= -44.15 \text{ m}$$

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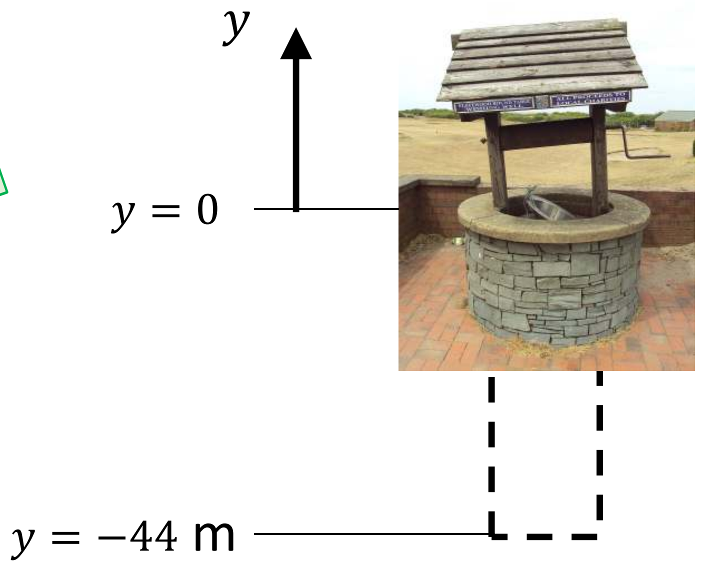
We could have chosen a smarter coordinate system!



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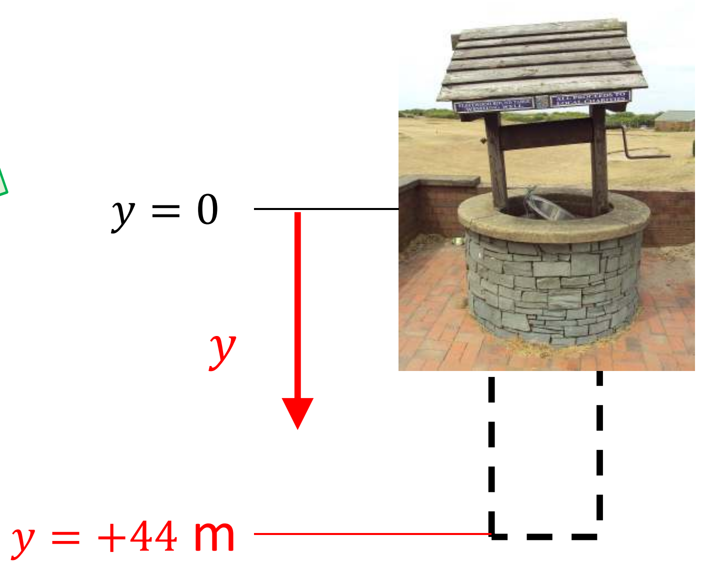

$$y = y_i + v_i t + \tfrac{1}{2}at^2$$

$$= 0 + (0)(3) + \tfrac{1}{2}(+9.81)(3)^2$$

$$= +44.15 \text{ m}$$

- Another one!

Example problem #2b

You drop a coin in a wishing well. After 3 seconds you hear a "plop".
How fast does it hit the water?

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How fast does it hit the water?

List of things given / to find:

- You "drop" the coin (not thrown): $v_i = 0$
- Time between drop and plop: $t = 3$ sec.
- We are looking for a speed: v
- We are free to choose $y_i = 0$
- Coin accelerates because of gravity: $a = 9.81$ m/s^2 (down)

Example problem #2b

You drop a coin in a wishing well. After 3 seconds you hear a "plop".
How fast does it hit the water?

List of things given / to find:

- You "drop" the coin (not thrown): $v_i = 0$
- Time between drop and plop: $t = 3$ sec.
- We are looking for a speed: v
- We are free to choose $y_i = 0$
- Coin accelerates because of gravity: $a = 9.81$ m/s^2 (down)

$$x = x_i + v_i t + \frac{1}{2}at^2$$

$$v = v_i + at$$

$$v^2 = v_i^2 + 2a(x - x_i)$$

Example problem #2b

You drop a coin in a wishing well. After 3 seconds you hear a "plop".
How fast does it hit the water?

List of things given / to find:

- You "drop" the coin (not thrown): $v_i = 0$
- Time between drop and plop: $t = 3$ sec.
- We are looking for a speed: v
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- Coin accelerates because of gravity: $a = 9.81$ m/s^2 (down)

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$$v = v_i + at$$

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Example problem #2b

You drop a coin in a wishing well. After 3 seconds you hear a "plop".
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- We are free to choose $y_i = 0$
- Coin accelerates because of gravity: $a = 9.81$ m/s^2 (down)

$$x = x_i + v_i t + \frac{1}{2} a t^2$$

$$v = v_i + at$$

$$v^2 = v_i^2 + 2a(x - x_i)$$

If you choose up to be positive:

$$v = 0 + (-9.81)(3) = -29.4 \text{ m/s}$$ (29.4 m/s going down)

- One more!

Example problem 3

You throw a ball straight up into the air, releasing it with a speed of 30 m/s. Assuming g = 10 m/s2, you catch the ball 6.0 seconds later at the same point from which you let it go. Neglect air resistance.

How high does the ball go?

Example problem 3

You throw a ball straight up into the air, releasing it with a speed of 30 m/s. Assuming g = 10 m/s2, you catch the ball 6.0 seconds later at the same point from which you let it go. Neglect air resistance.

How high does the ball go?

List of things given / to find:

- You throw the ball up: $v_i = 30$ m/s (up)
- Total time: $t = 6$ sec.
- We are looking for a height: y
- We are free to choose $y_i = 0$
- Ball accelerates because of gravity: $a = g = 10$ m/s² (down)

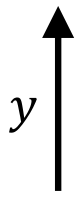
$$x = x_i + v_i t + \frac{1}{2}at^2$$

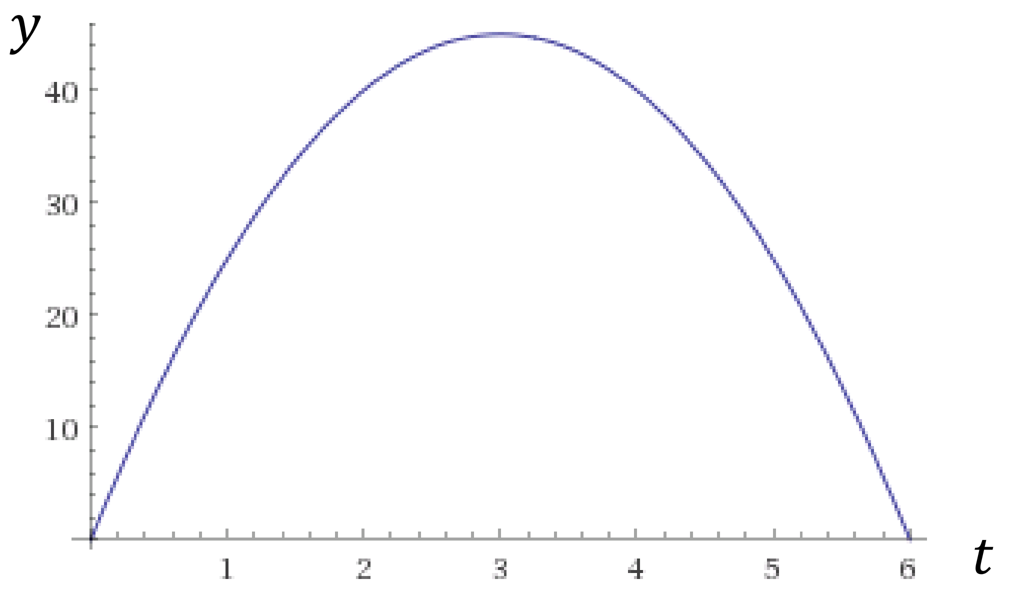
$$v = v_i + at$$

$$v^2 = v_i^2 + 2a(x - x_i)$$

Where the ball is at time t, is given by:

$$y = y_i + v_i t - \frac{1}{2}gt^2$$





Example problem 3

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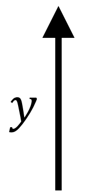
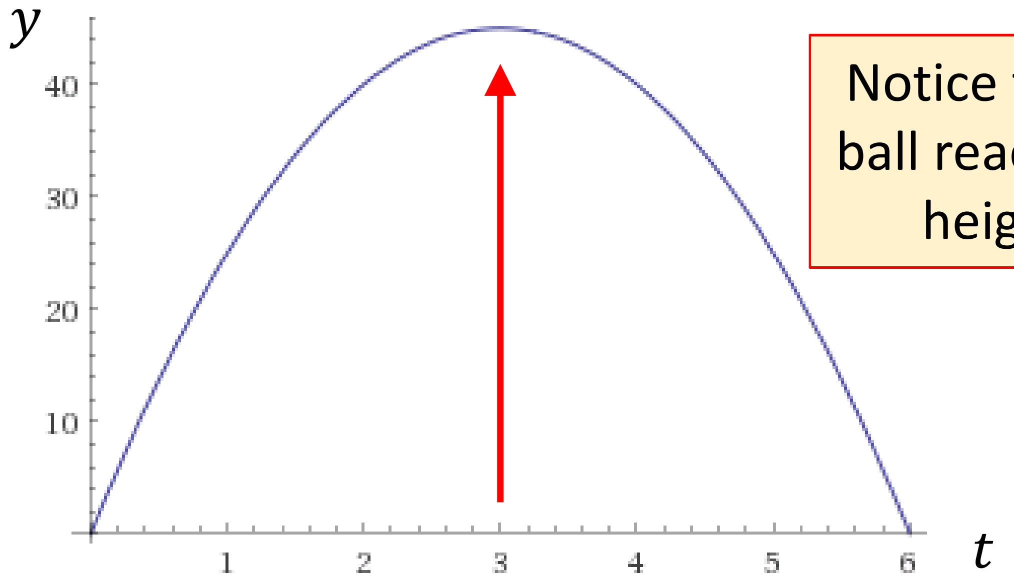




Notice the symmetry: ball reaches maximum height at 3 sec.

Example problem 3

You throw a ball straight up into the air, releasing it with a speed of 30 m/s. Assuming g = 10 m/s2, you catch the ball 6.0 seconds later at the same point from which you let it go. Neglect air resistance.

How high does the ball go?

List of things given / to find:

- You throw the ball up: $v_i = 30$ m/s (up)
- Total time: $t = 6$ sec.
- We are looking for a height: y
- We are free to choose $y_i = 0$
- Ball accelerates because of gravity: $a = g = 10$ m/s² (down)

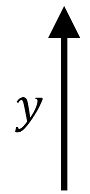
$$x = x_i + v_i t + \frac{1}{2} a t^2$$

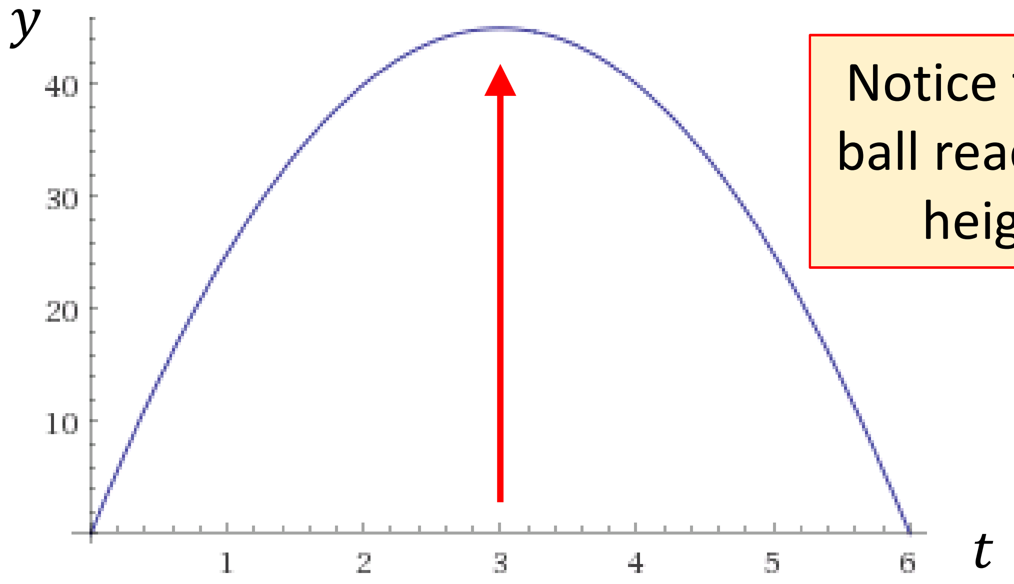
$$v = v_i + at$$

$$v^2 = v_i^2 + 2a(x - x_i)$$

Where the ball is at time t, is given by:

$$y = y_i + v_i t - \frac{1}{2} g t^2$$





Notice the symmetry: ball reaches maximum height at 3 sec.

$$y = y_i + v_i t - \frac{1}{2} g t^2 = 0 + (30)(3) - \frac{1}{2}(10)(3^2) = 90 - 45 = 45 \text{ m}$$

- Time for another one?

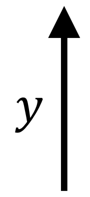
Example problem 3

You throw a ball straight up into the air, releasing it with a speed of 30 m/s. Assuming g = 10 m/s2, you catch the ball 6.0 seconds later at the same point from which you let it go. Neglect air resistance.

How high does the ball go? **How fast does it hit the ground?**

List of things given / to find:

- You throw the ball up: $v_i = 30$ m/s (up)
- Total time: $t = 6$ sec.
- We are looking for a height: y
- We are free to choose $y_i = 0$
- Ball accelerates because of gravity: $a = g = 10$ m/s² (down)



$$v = v_i + at = 30 - (10)(6) = -30 \text{ m/s}$$

$$x = x_i + v_i t + \tfrac{1}{2}at^2$$

$$v = v_i + at$$

$$v^2 = v_i^2 + 2a(x - x_i)$$

- Come to office hours if you have more questions:
    - Today 4-5pm in SCI-121

- Or ask on Piazza!

- HW 2 is due tomorrow at midnight (Tuesday 31 Jan at 11:59pm)

Thank you!

See you next time: Wednesday 1 Feb. at 2:30pm