TODAY:
FALLING.

Did you get my test email?

Sarah Burke Spolaor - sbs0016@mix.wvu.edu <WVUeCampus@wvu.edu> 11:17 AM (0 minutes ago)

to

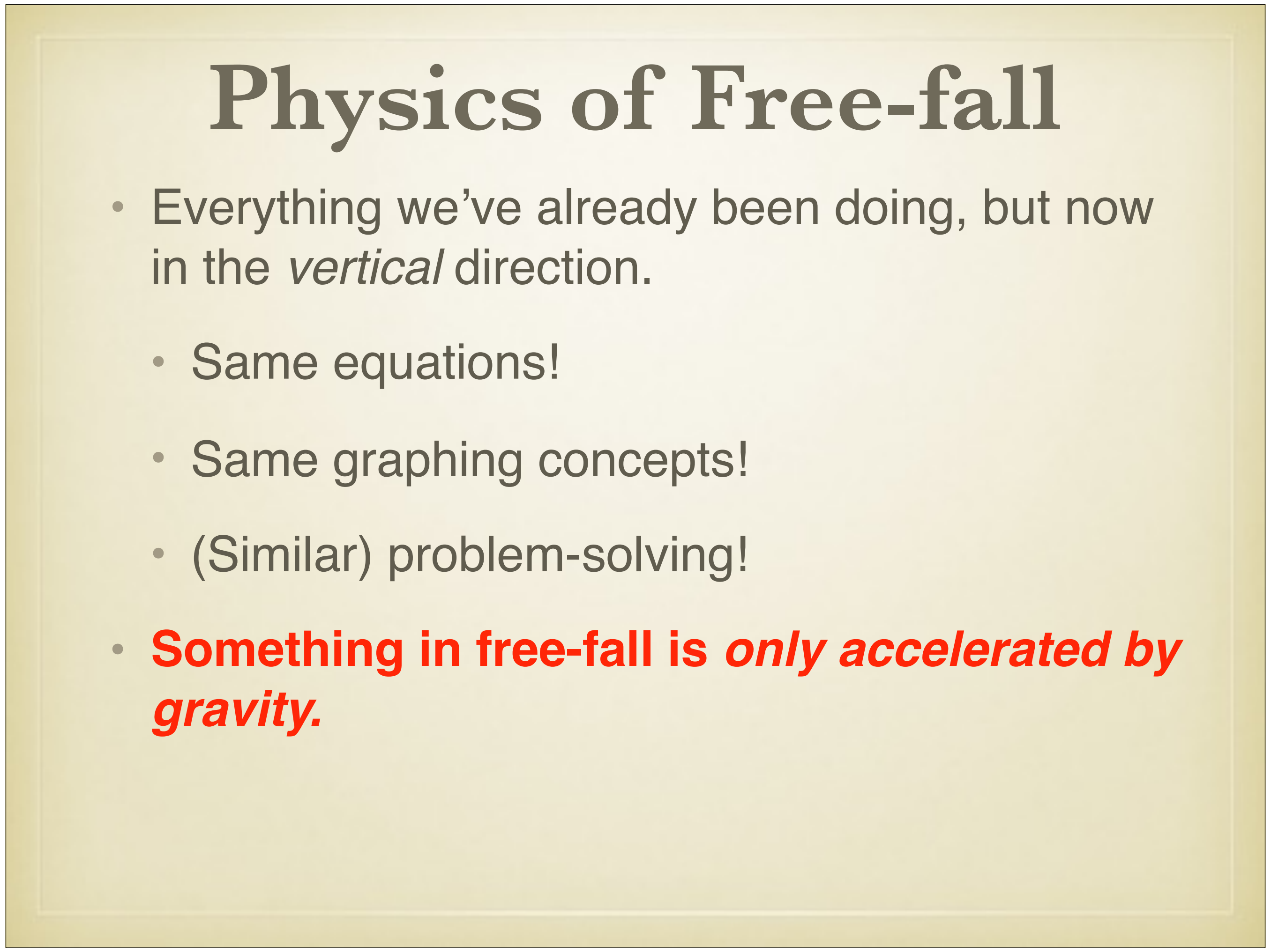
Hi all,

Just re-testing the eCampus email system; it seems students may be getting them to their SPAM boxes. In class today I will ask you if you got this email.

See you soon,
Prof Sarah

- If not, make sure it's not in your junk box, and add sbs0016@mix.wvu.edu to your address book!
- Also please email me to let me know.

I will be emailing out practice problems and info about the test!



Physics of Free-fall

- Everything we've already been doing, but now in the *vertical* direction.
  - Same equations!
  - Same graphing concepts!
  - (Similar) problem-solving!
- **Something in free-fall is *only accelerated by gravity.***

We're still using 1d, but now turning it in the vertical direction
Definition time: Things "freely falling" can be going up or down.
Practice: 2.45, 2.47, 2.53, 2.59, 2.61, 2.63, 2.69, Multiple Choice 2.1

There's no air in this lecture!

In our free-fall discussions we will assume there is no air resistance. Regarding this, there's a fundamental BUT very common misconception to address first. Which is that: everything experiences the same amount of acceleration. Acceleration implies change in velocity, so all things have a velocity that changes at the same rate.
WHAT DOES THIS MEAN? ………
When there's no air, HEAVIER THINGS DON'T FALL FASTER!

There’s no air in this lecture!

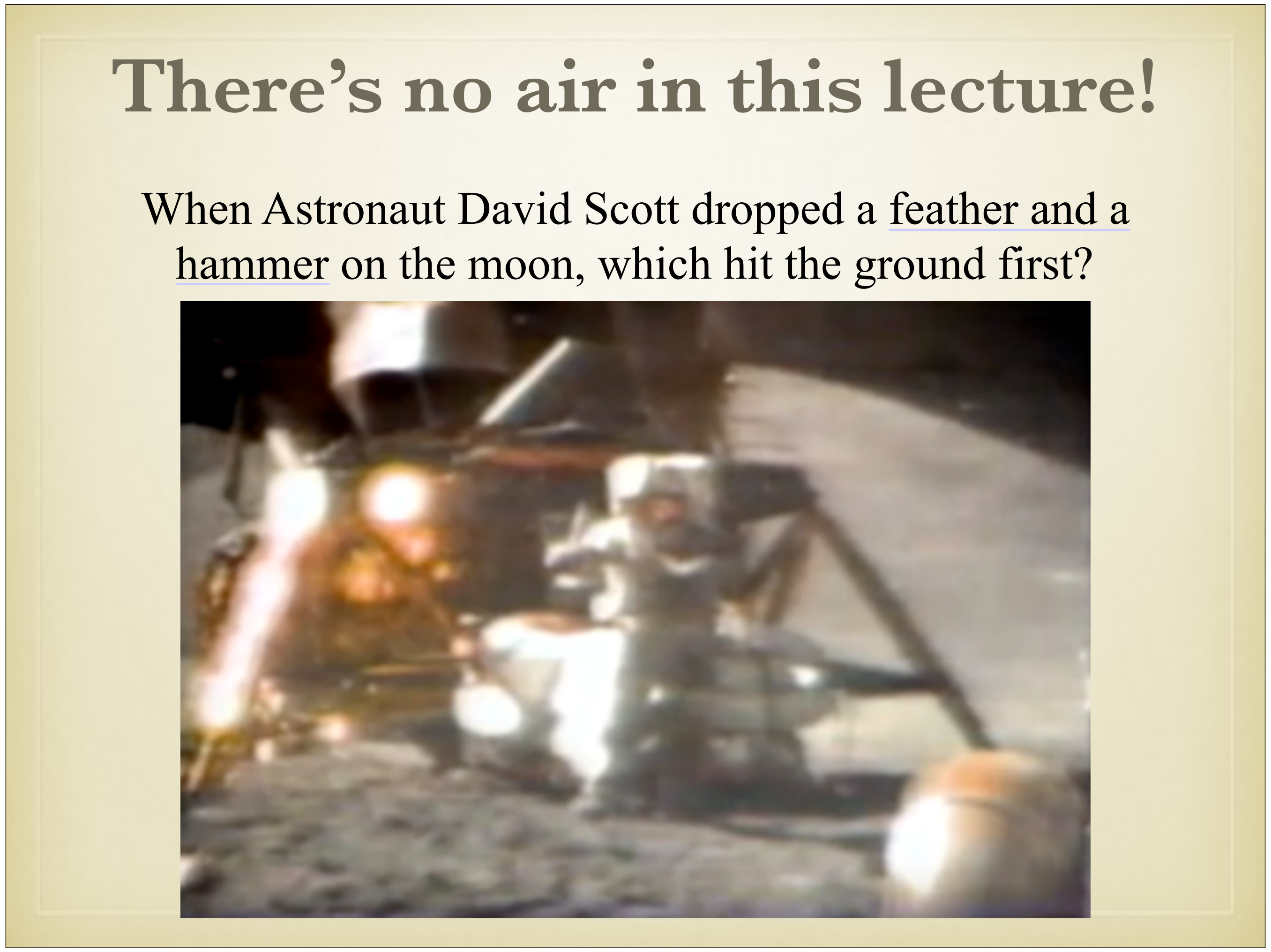
Heavier things DON’T fall faster!

(but things with less air resistance do)

In our free-fall discussions we will assume there is no air resistance. Regarding this, there’s a fundamental BUT very common misconception to address first. Which is that: everything experiences the same amount of acceleration. Acceleration implies change in velocity, so all things have a velocity that changes at the same rate.

WHAT DOES THIS MEAN? ………

When there’s no air, HEAVIER THINGS DON’T FALL FASTER!



There’s no air in this lecture!

When Astronaut David Scott dropped a feather and a hammer on the moon, which hit the ground first?

Introduce and show video…
This is also true on Earth. DO DEMO.
If you take out the air, everything falls at the same rate. The velocity of both the penny and the feather changes in the same way. So: ALL THINGS EXPERIENCE THE SAME ACCELERATION!

David Scott hammer and feather in a vacuum:
https://www.youtube.com/watch?v=KDp1tiUsZw8

There’s no air in this lecture!

When Astronaut David Scott dropped a feather and a hammer on the moon, which hit the ground first?

Introduce and show video…
This is also true on Earth. DO DEMO.
If you take out the air, everything falls at the same rate. The velocity of both the penny and the feather changes in the same way. So: ALL THINGS EXPERIENCE THE SAME ACCELERATION!

David Scott hammer and feather in a vacuum:
https://www.youtube.com/watch?v=KDp1tiUsZw8

A simplifying assumption…

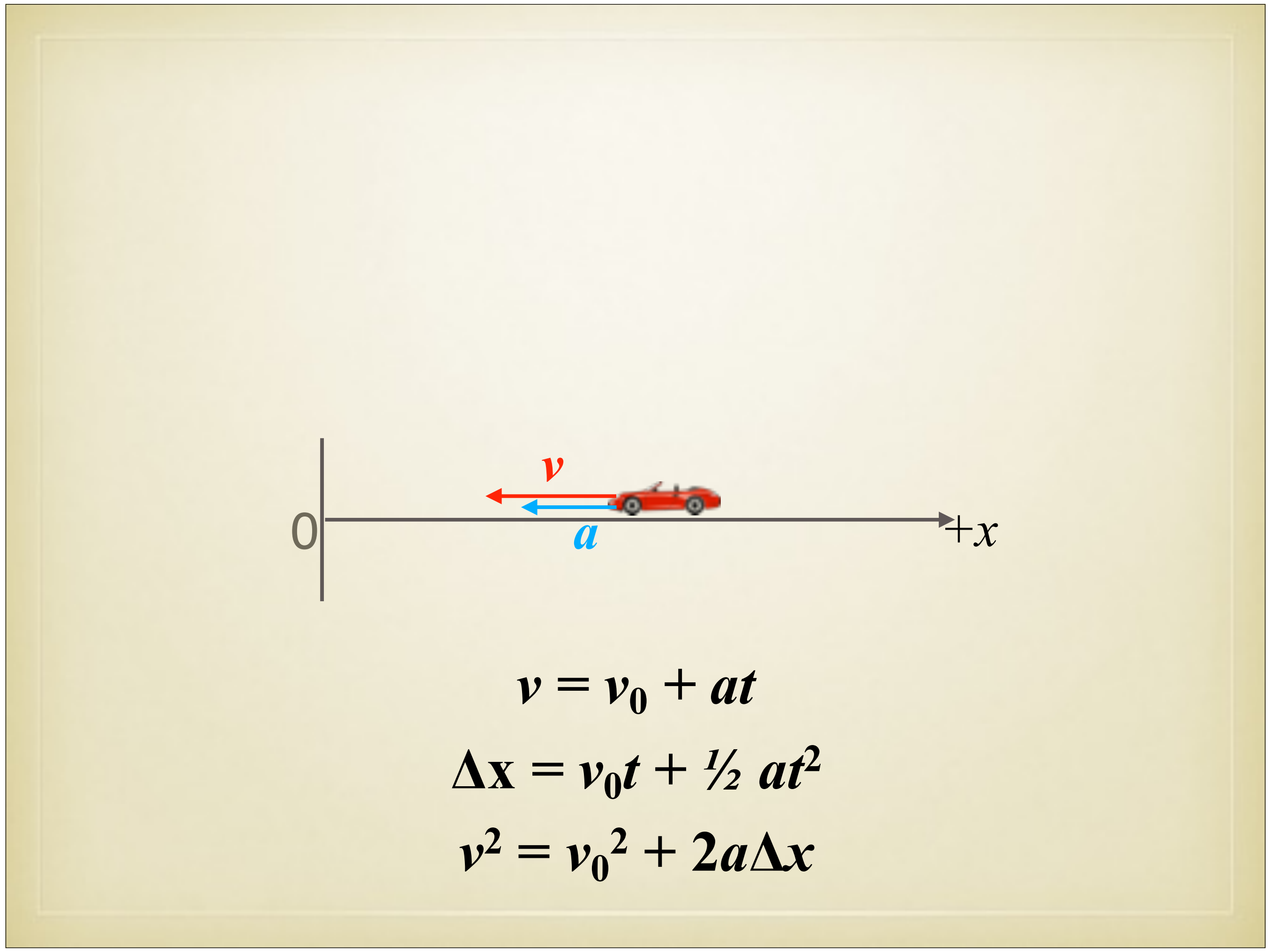
"Near" Earth*,
all objects have the
same constant acceleration:

$$g = 9.8\ \mathrm{m/s^2}$$

towards the center of the Earth.

*Later we will consider extremely high altitudes (beyond atmosphere)

For the purposes of our work for most of this course, this makes things very easy: all things are affected by the same, constant, acceleration.
This is the acceleration caused by the gravity of Earth, and it has a magnitude of ~9.8 m/s2 TOWARDS THE CENTER OF THE EARTH.
You saw this g in your homework.

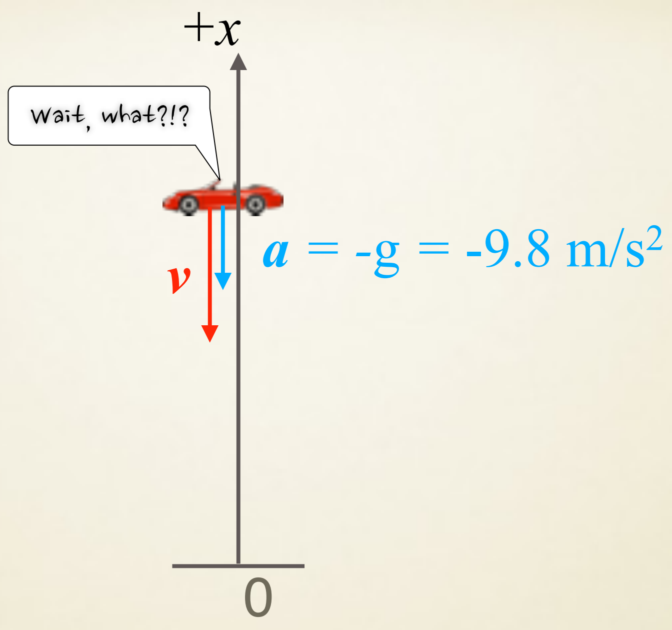


$$v = v_0 + at$$

$$\Delta x = v_0 t + ½ at^2$$

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

Just want to insist how easy a translation this should be for you. Ready? This is the *only thing* that is changing.



$a = -g = -9.8\ \mathrm{m/s^2}$

$$v = v_0 + at$$

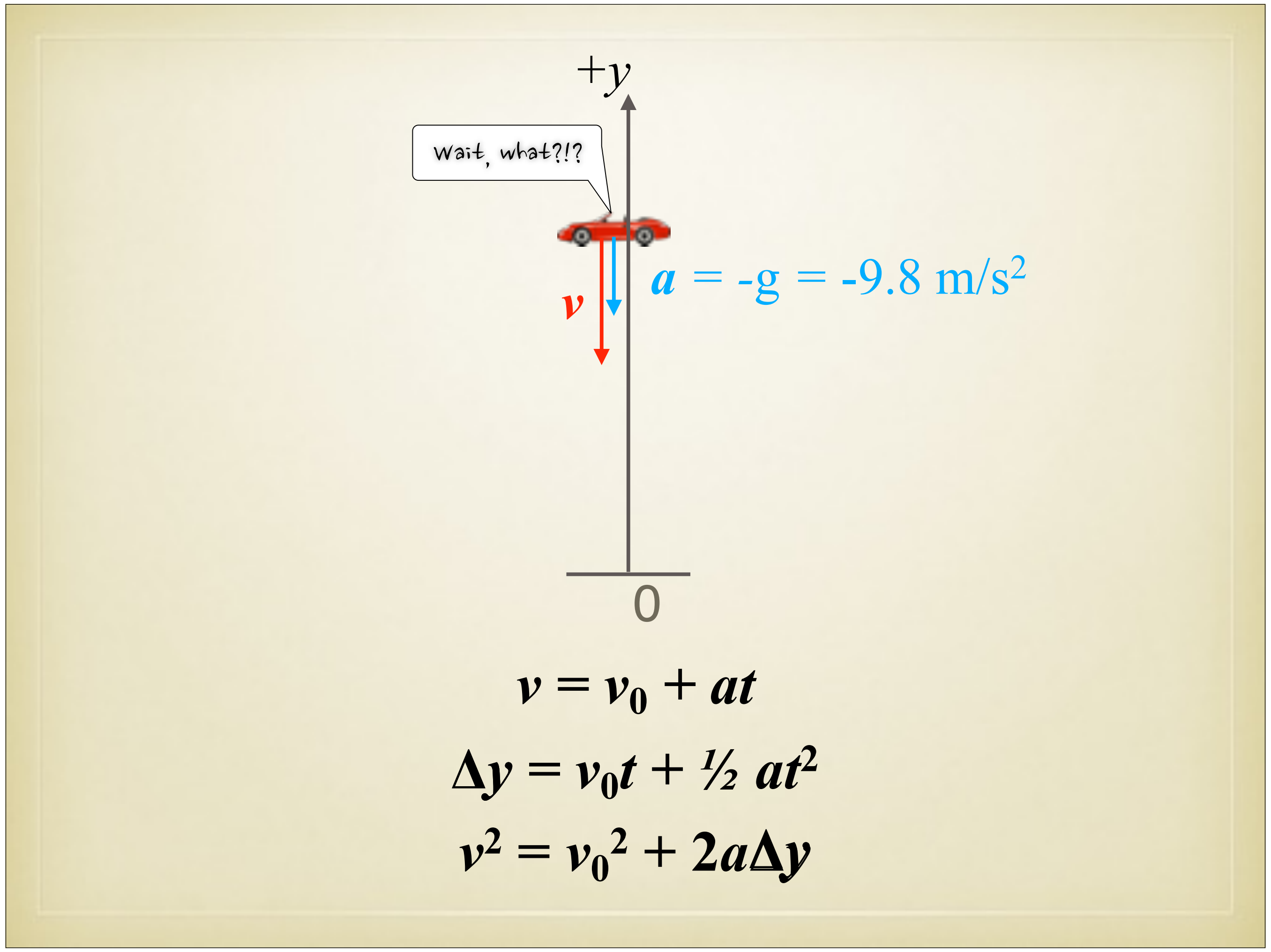
$$\Delta x = v_0 t + \tfrac{1}{2} a t^2$$

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

Now the acceleration is always constant

We commonly call vertical axis y, so you occasionally see, and in the book you will see, vertical falling written like this. This is good practice because in the next weeks, we will discuss motion in both the x and y direction, so we will practice doing this now.

BIG THING TO NOTE: the *magnitude* of the gravitational acceleration is 9.8 m/s^2 but the sign DEPENDS ON YOUR AXES!



$$v = v_0 + at$$

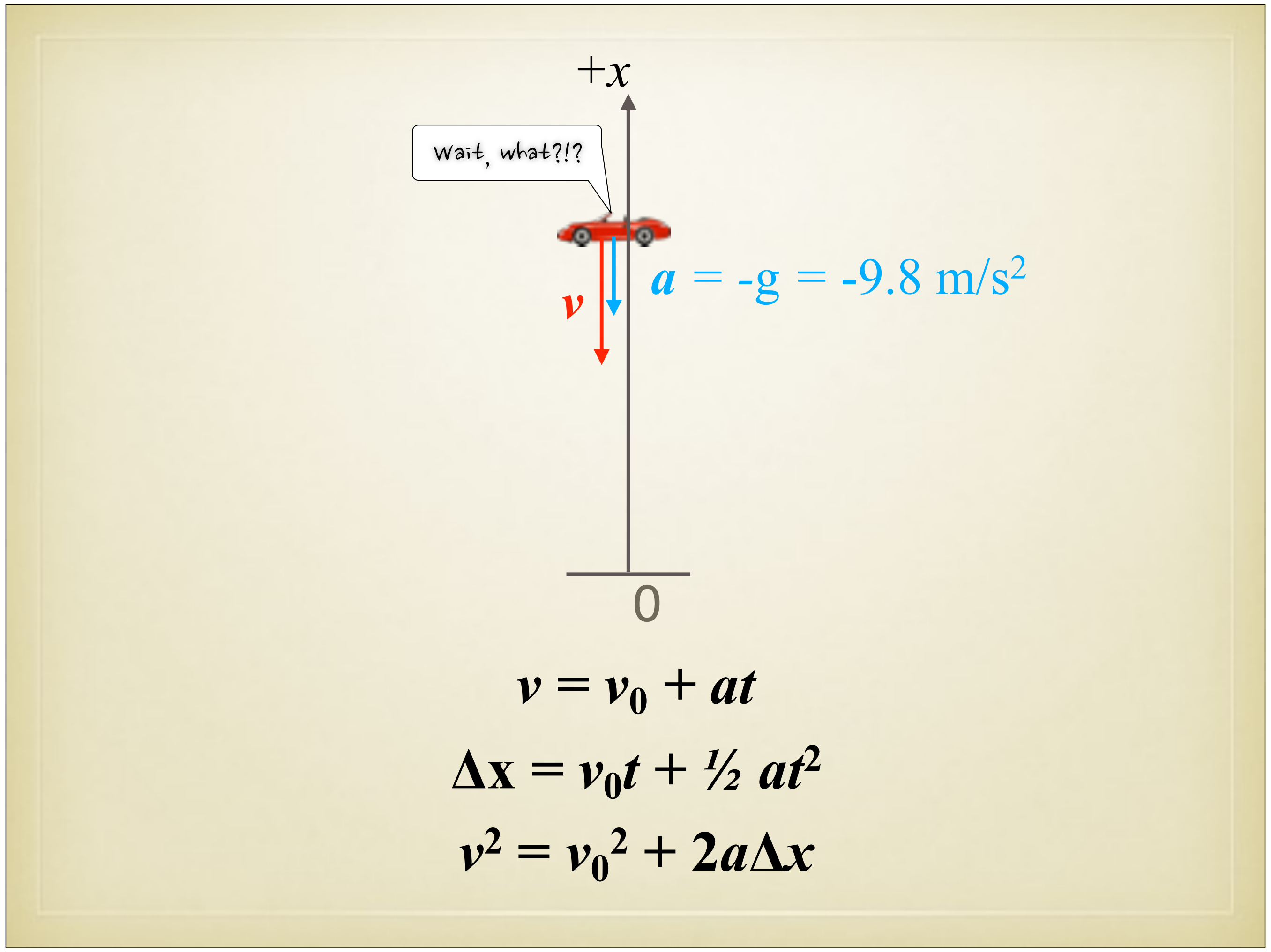
$$\Delta y = v_0 t + \tfrac{1}{2} at^2$$

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

Now the acceleration is always constant

We commonly call vertical axis y, so you occasionally see, and in the book you will see, vertical falling written like this. This is good practice because in the next weeks, we will discuss motion in both the x and y direction, so we will practice doing this now.

BIG THING TO NOTE: the *magnitude* of the gravitational acceleration is 9.8 m/s^2 but the sign DEPENDS ON YOUR AXES!



$$v = v_0 + at$$

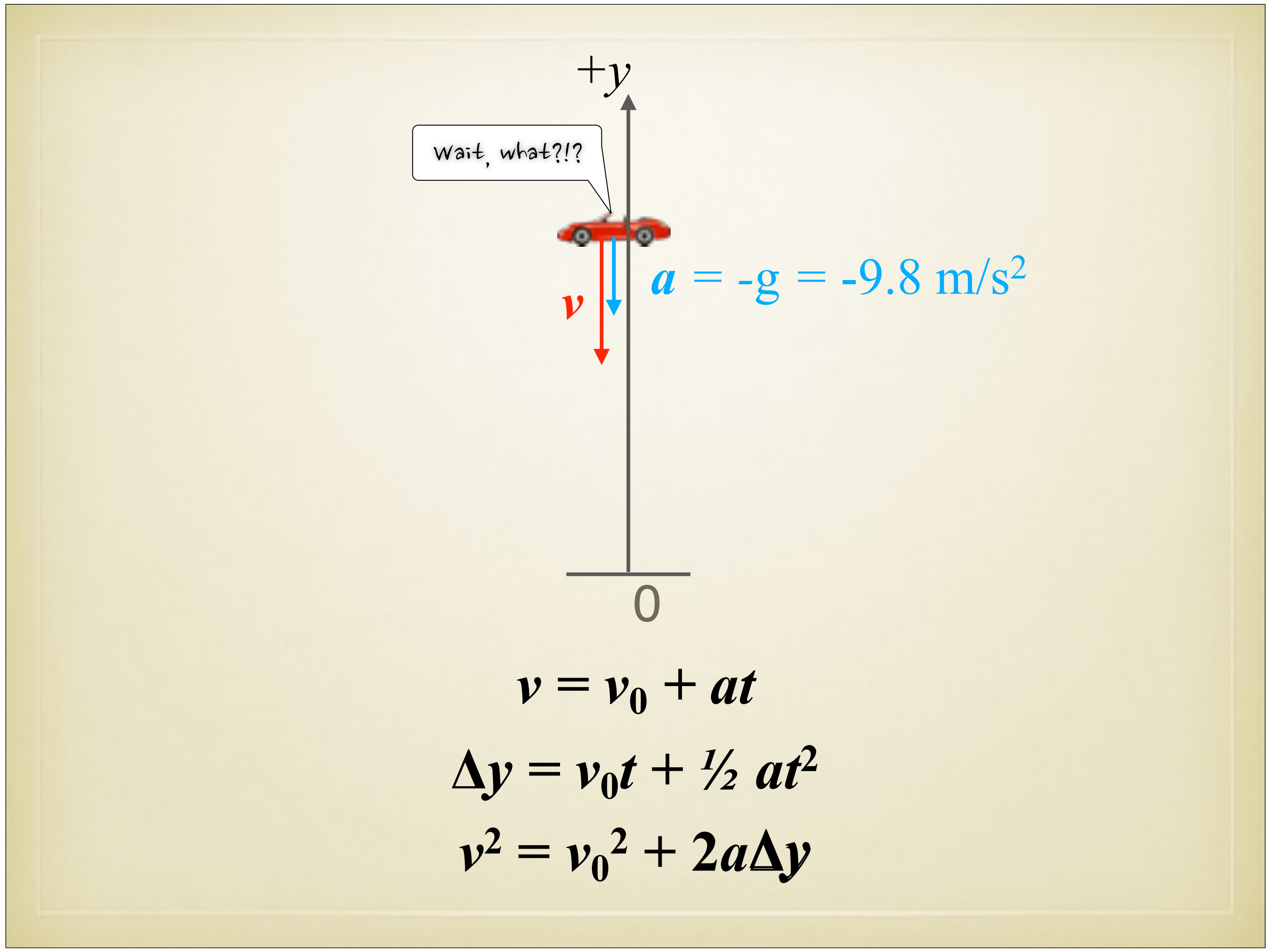
$$\Delta x = v_0 t + \tfrac{1}{2} at^2$$

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

Now the acceleration is always constant

We commonly call vertical axis y, so you occasionally see, and in the book you will see, vertical falling written like this. This is good practice because in the next weeks, we will discuss motion in both the x and y direction, so we will practice doing this now.

BIG THING TO NOTE: the *magnitude* of the gravitational acceleration is 9.8 m/s^2 but the sign DEPENDS ON YOUR AXES!



$$v = v_0 + at$$

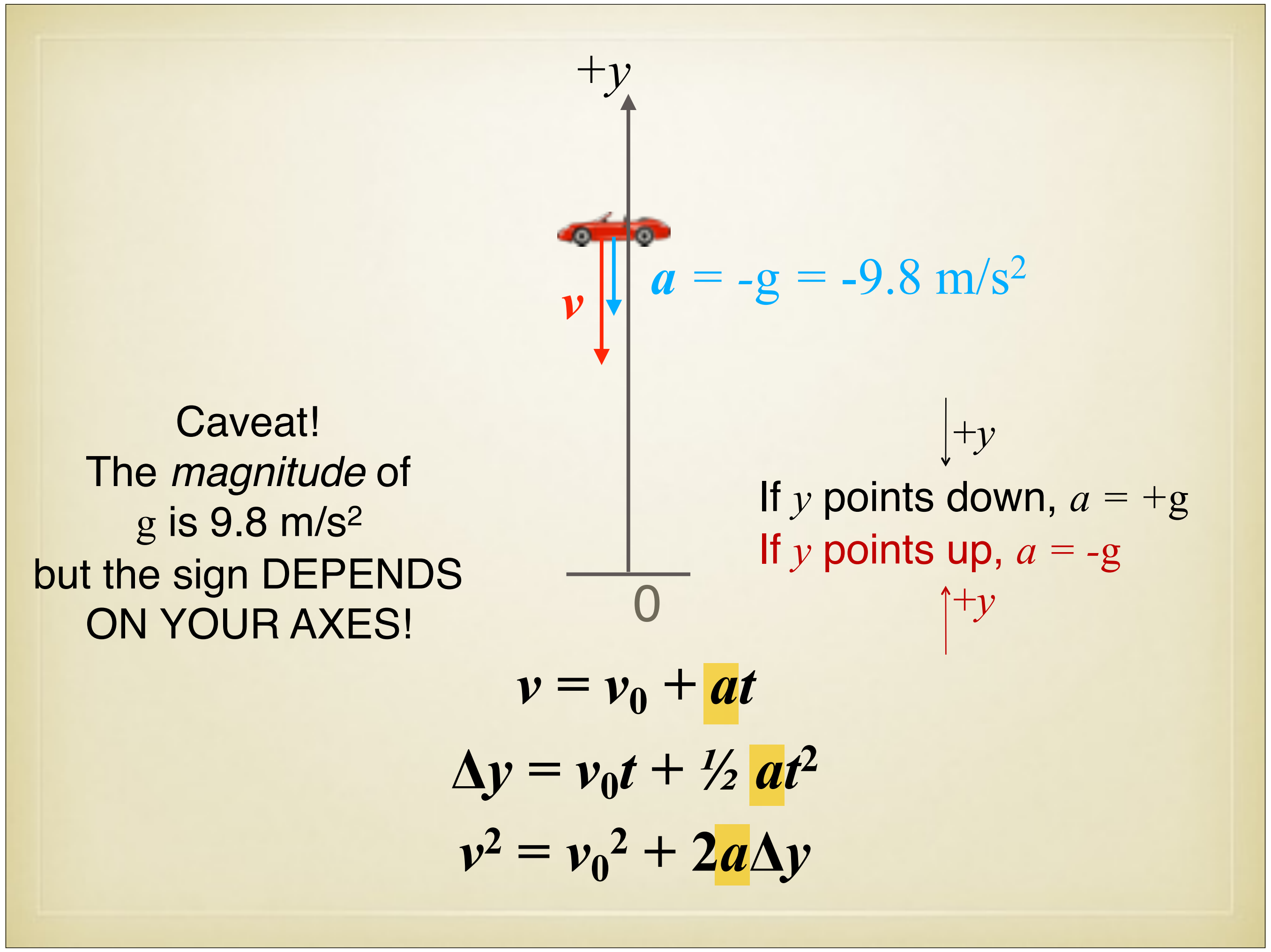
$$\Delta y = v_0 t + \tfrac{1}{2} at^2$$

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

Now the acceleration is always constant

We commonly call vertical axis y, so you occasionally see, and in the book you will see, vertical falling written like this. This is good practice because in the next weeks, we will discuss motion in both the x and y direction, so we will practice doing this now.

BIG THING TO NOTE: the *magnitude* of the gravitational acceleration is 9.8 m/s^2 but the sign DEPENDS ON YOUR AXES!



$a = -g = -9.8 \text{ m/s}^2$

Caveat!
The *magnitude* of
g is 9.8 m/s^2
but the sign DEPENDS
ON YOUR AXES!

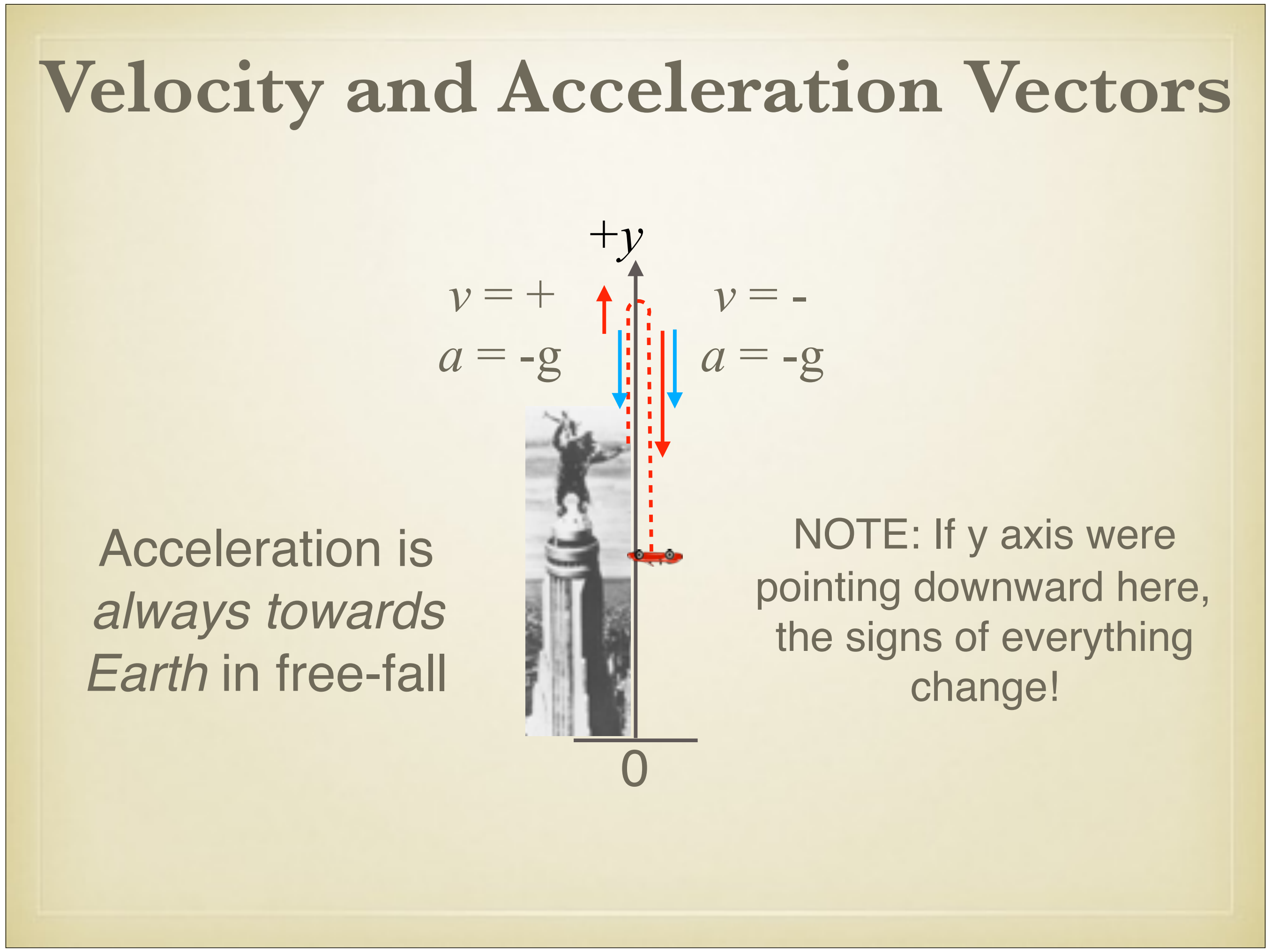
If y points down, $a = +g$
If y points up, $a = -g$

$$v = v_0 + at$$

$$\Delta y = v_0 t + \tfrac{1}{2} at^2$$

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

BIG THING TO NOTE: the *magnitude* of the gravitational acceleration is 9.8 m/s^2 but the sign DEPENDS ON YOUR AXES!
This acceleration always points towards the Earth, so here a = -g

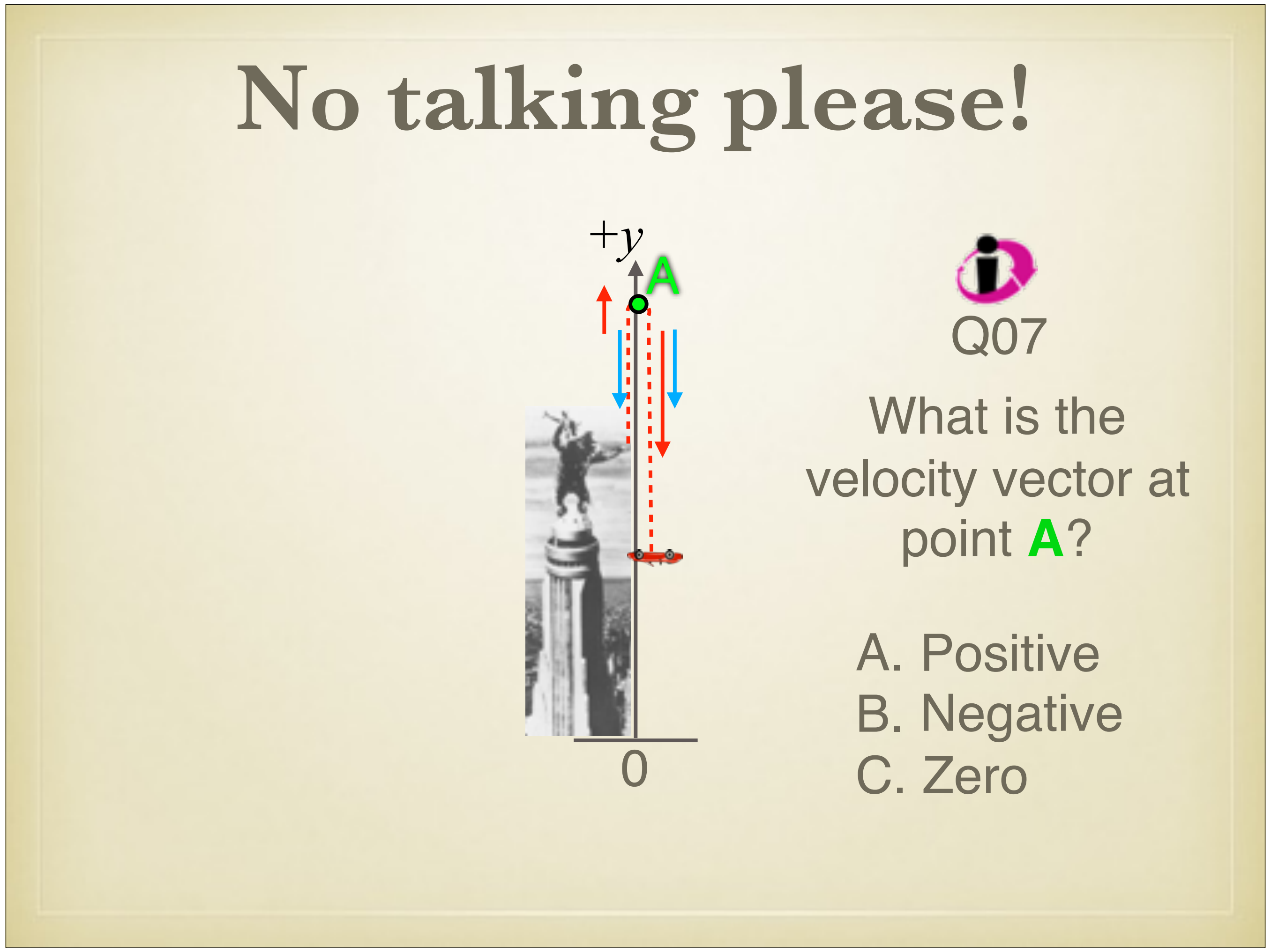


Velocity and Acceleration Vectors

Acceleration is *always towards Earth* in free-fall

NOTE: If y axis were pointing downward here, the signs of everything change!

There's something I beg you to NOT OVERTHINK when you're writing down the math! This is: regardless of whether you're on the upward or downward phase of the trip, acceleration is always towards Earth. Everyone knows that gravity never pushes things *upward,* but for some reason when we start talking about vectors people get befuddled. Velocity vectors do what they do, but gravitational acceleration vectors *alway points downward*.



No talking please!

Q07

What is the velocity vector at point **A**?

A. Positive
B. Negative
C. Zero

Please don’t speak to your neighbor.

Answer: C.

Velocity gets smaller and smaller until it hits 0 and becomes negative.

Let's try it!

You toss an orange and it reaches a height 10ft
above where you released it.
How long does it take to reach this height?

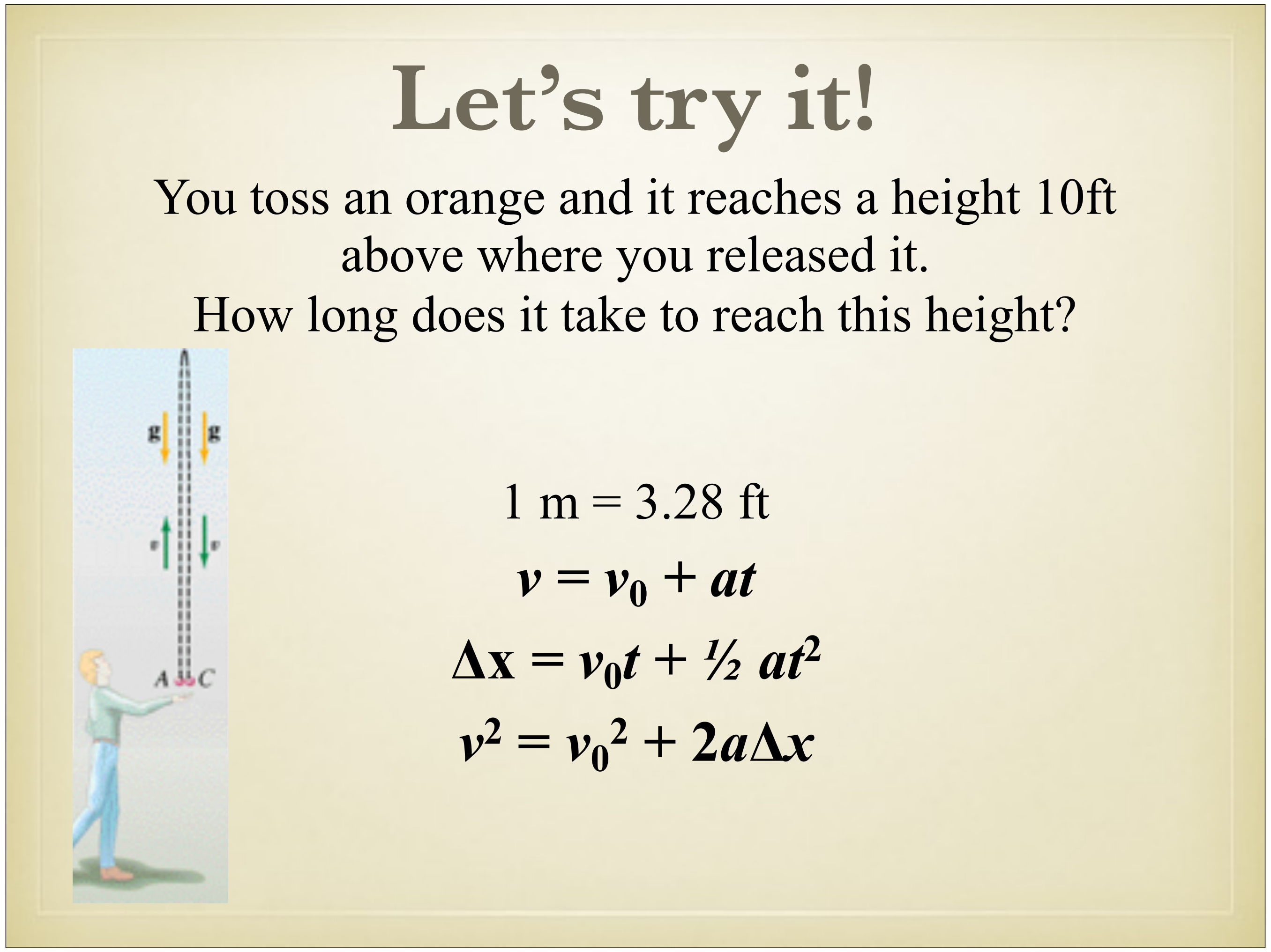
1 m = 3.28 ft

$$v = v_0 + at$$

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

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

DID ON LIGHT BOARD.
[solution will be posted online]



Let’s try it!

You toss an orange and it reaches a height 10ft above where you released it.
How long does it take to reach this height?

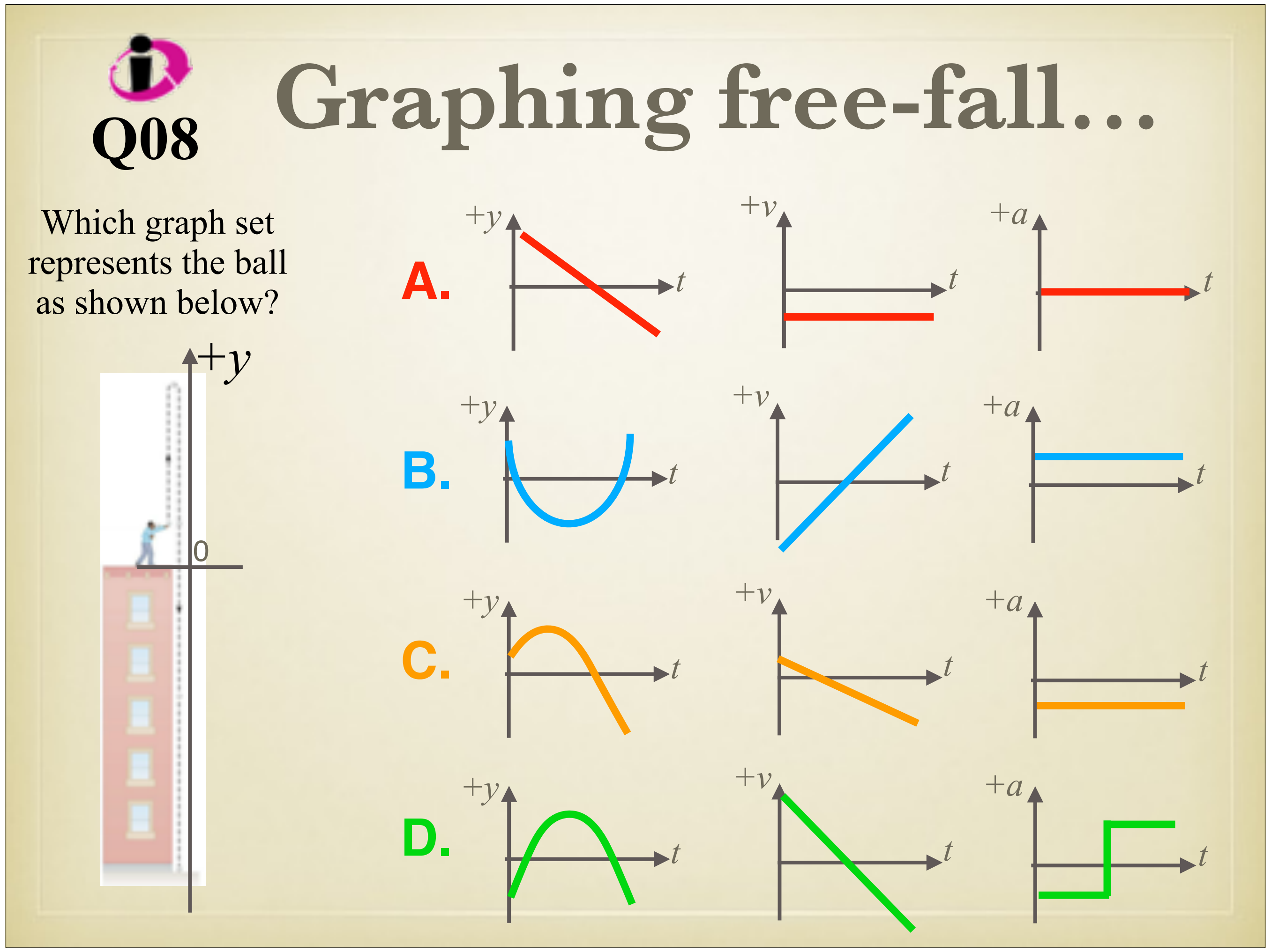
1 m = 3.28 ft

$$v = v_0 + at$$

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

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

DID ON LIGHT BOARD.
[solution will be posted online]



Q08

Graphing free-fall…

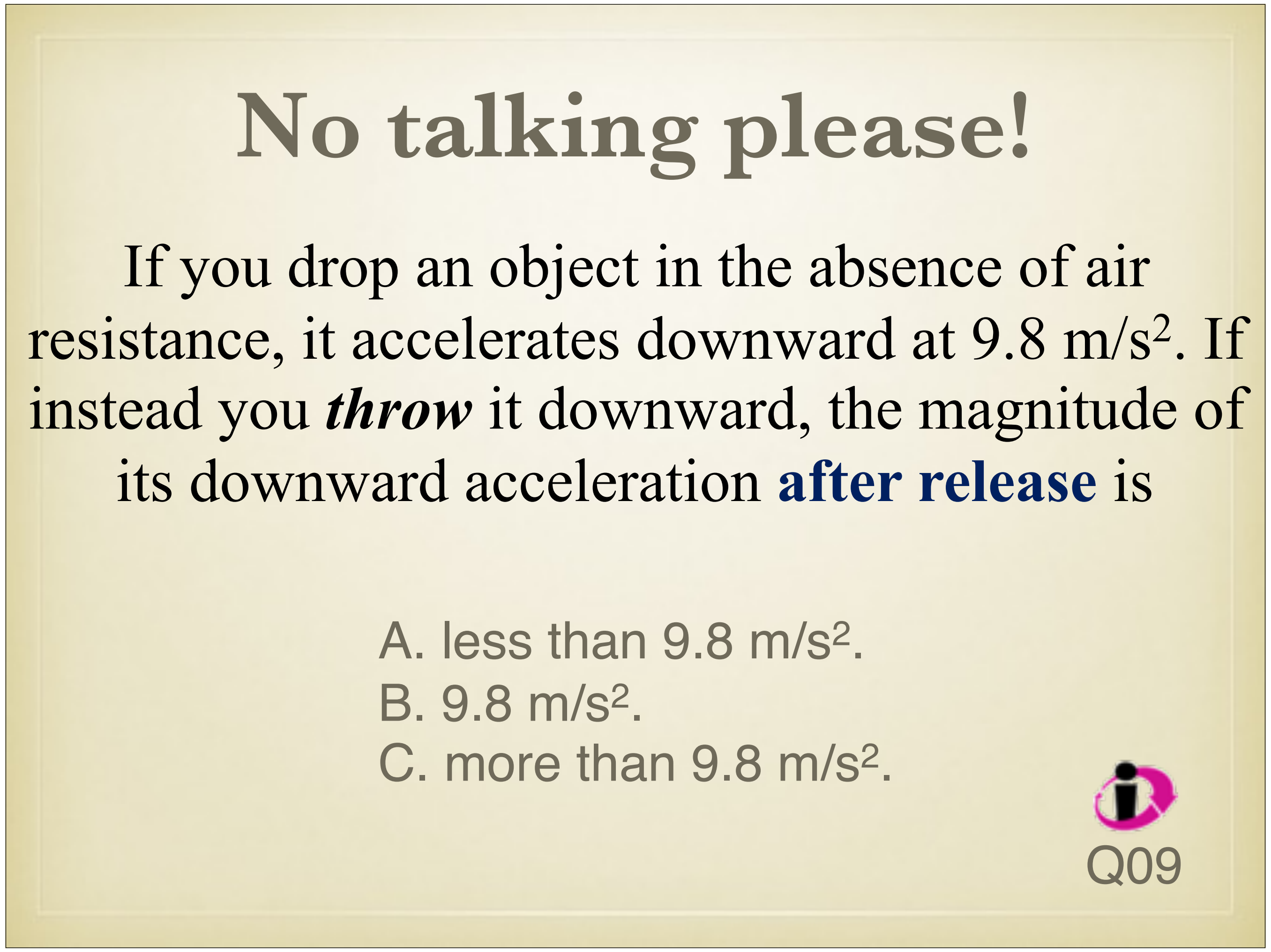
Which graph set represents the ball as shown below?

ANSWER: C.

Please chat with your neighbor.

Let’s tie this back to the last lecture and I want you to tell me which graph corresponds to the motion of the ball.

Things: NEGATIVE CONSTANT ACCELERATION (look at graphs).



No talking please!

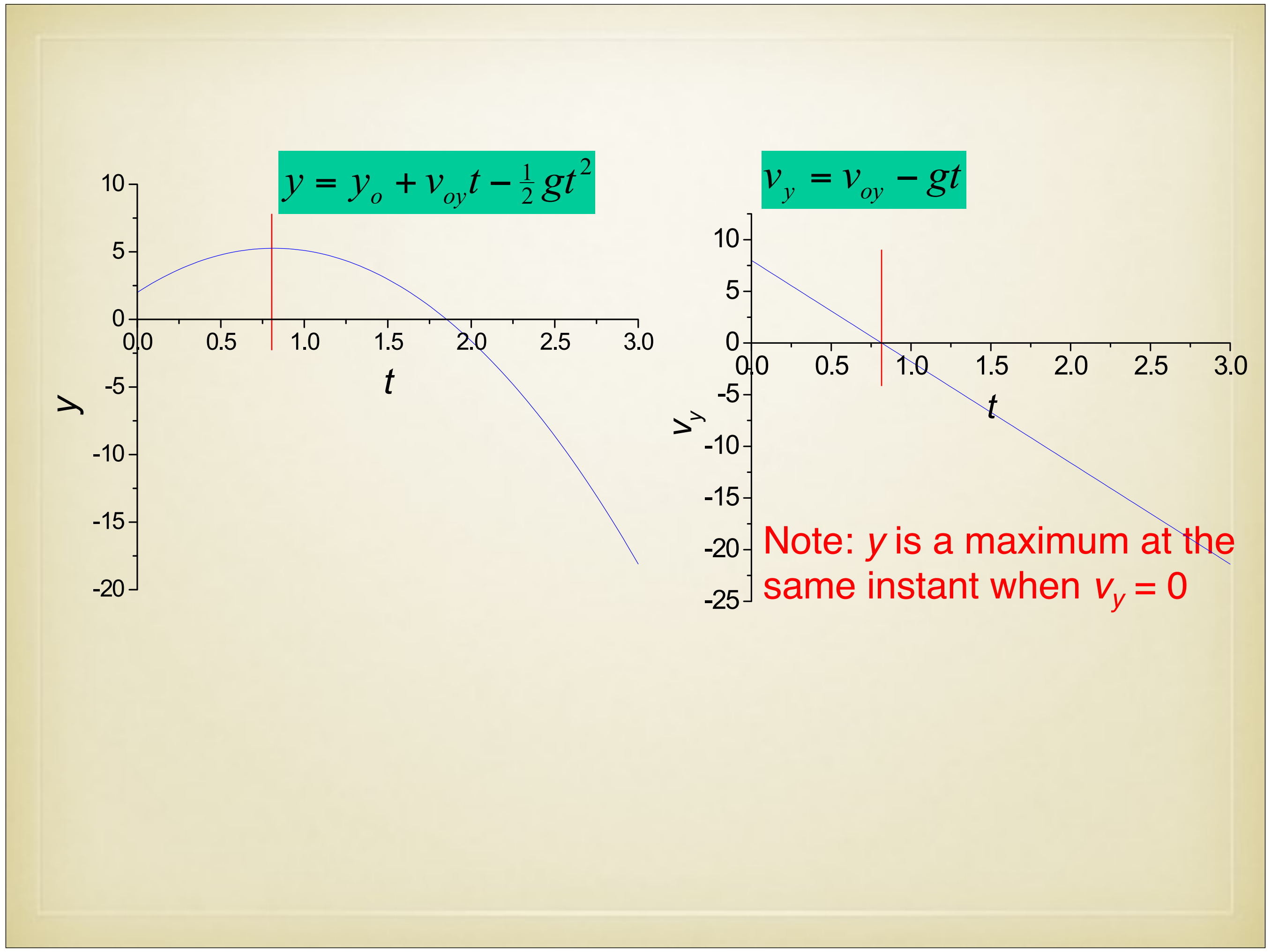
If you drop an object in the absence of air resistance, it accelerates downward at 9.8 m/s^2. If instead you ***throw*** it downward, the magnitude of its downward acceleration **after release** is

A. less than 9.8 m/s^2.
B. 9.8 m/s^2.
C. more than 9.8 m/s^2.

Q09

Answer: B.The acceleration of gravity is a constant, independent of initial velocity.

You WILL run into tricks like this in your homework and on test THINK and READ and DRAW if you need to!



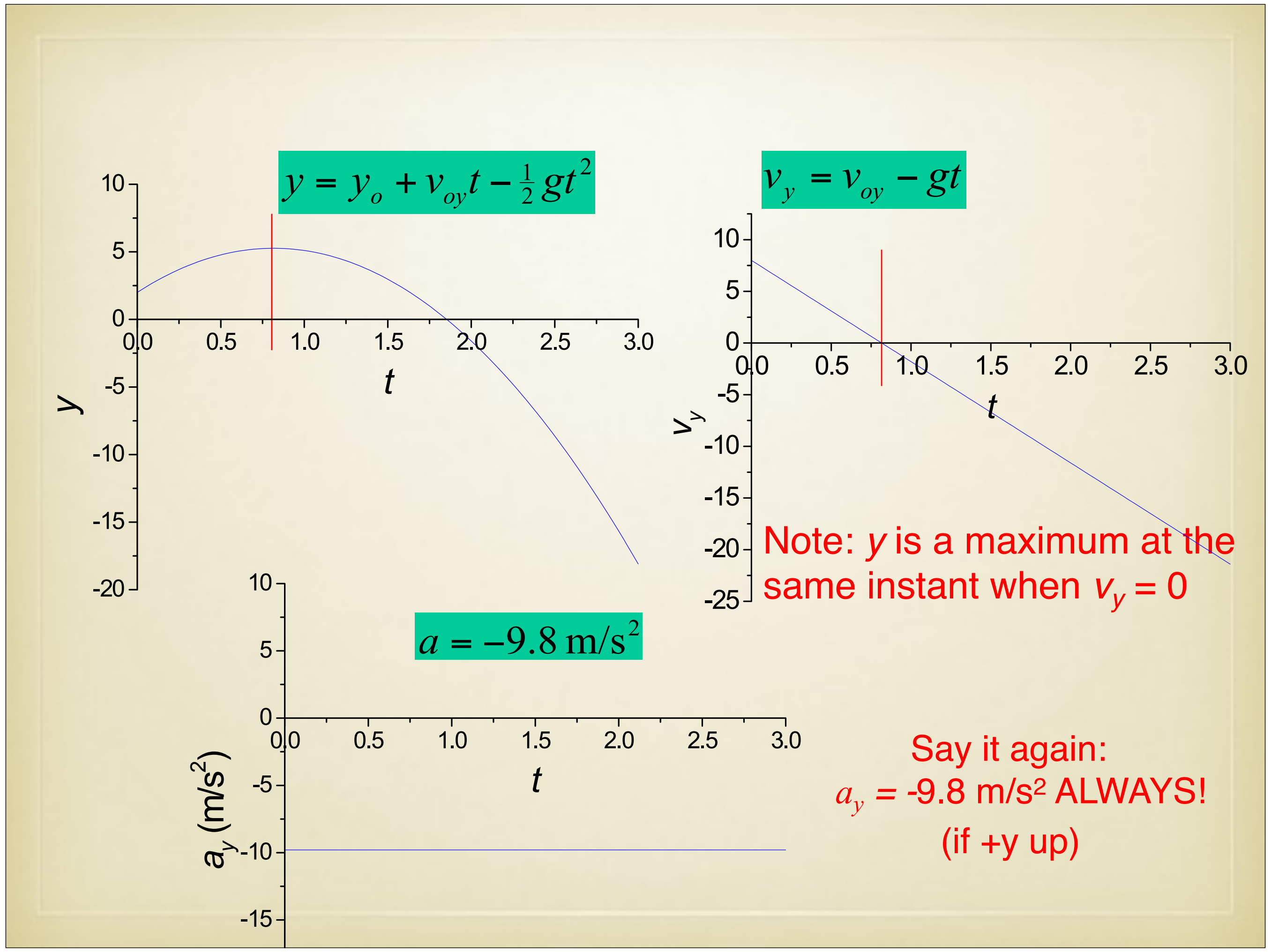
$y = y_o + v_{oy}t - \frac{1}{2}gt^2$

$v_y = v_{oy} - gt$

Note: *y* is a maximum at the same instant when $v_y = 0$

These are not cartoons. Here I've actually plotted the motion equations as y and v as a function of t.

Now I'd like YOU to do a problem, and It's going to be a *conceptual* problem.



$y = y_o + v_{oy}t - \frac{1}{2}gt^2$

$v_y = v_{oy} - gt$

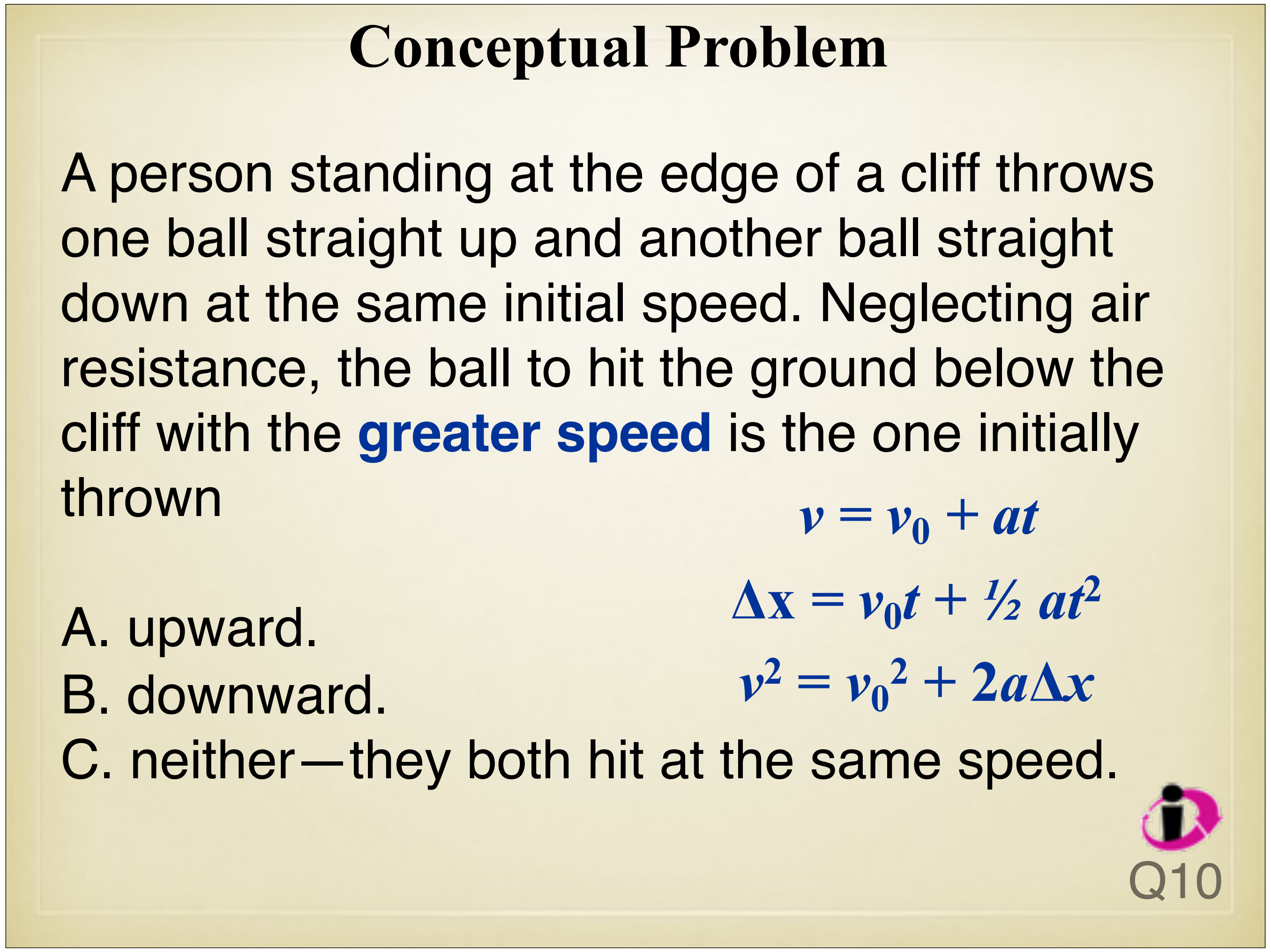
$a = -9.8\ \mathrm{m/s^2}$

Note: y is a maximum at the same instant when $v_y = 0$

Say it again:
a_y = -9.8 m/s² ALWAYS!
(if +y up)

These are not cartoons. Here I’ve actually plotted the motion equations as y and v as a function of t.

Now I’d like YOU to do a problem, and It’s going to be a *conceptual* problem.



Conceptual Problem

A person standing at the edge of a cliff throws one ball straight up and another ball straight down at the same initial speed. Neglecting air resistance, the ball to hit the ground below the cliff with the **greater speed** is the one initially thrown

$$v = v_0 + at$$

$$\Delta x = v_0 t + \tfrac{1}{2} at^2$$

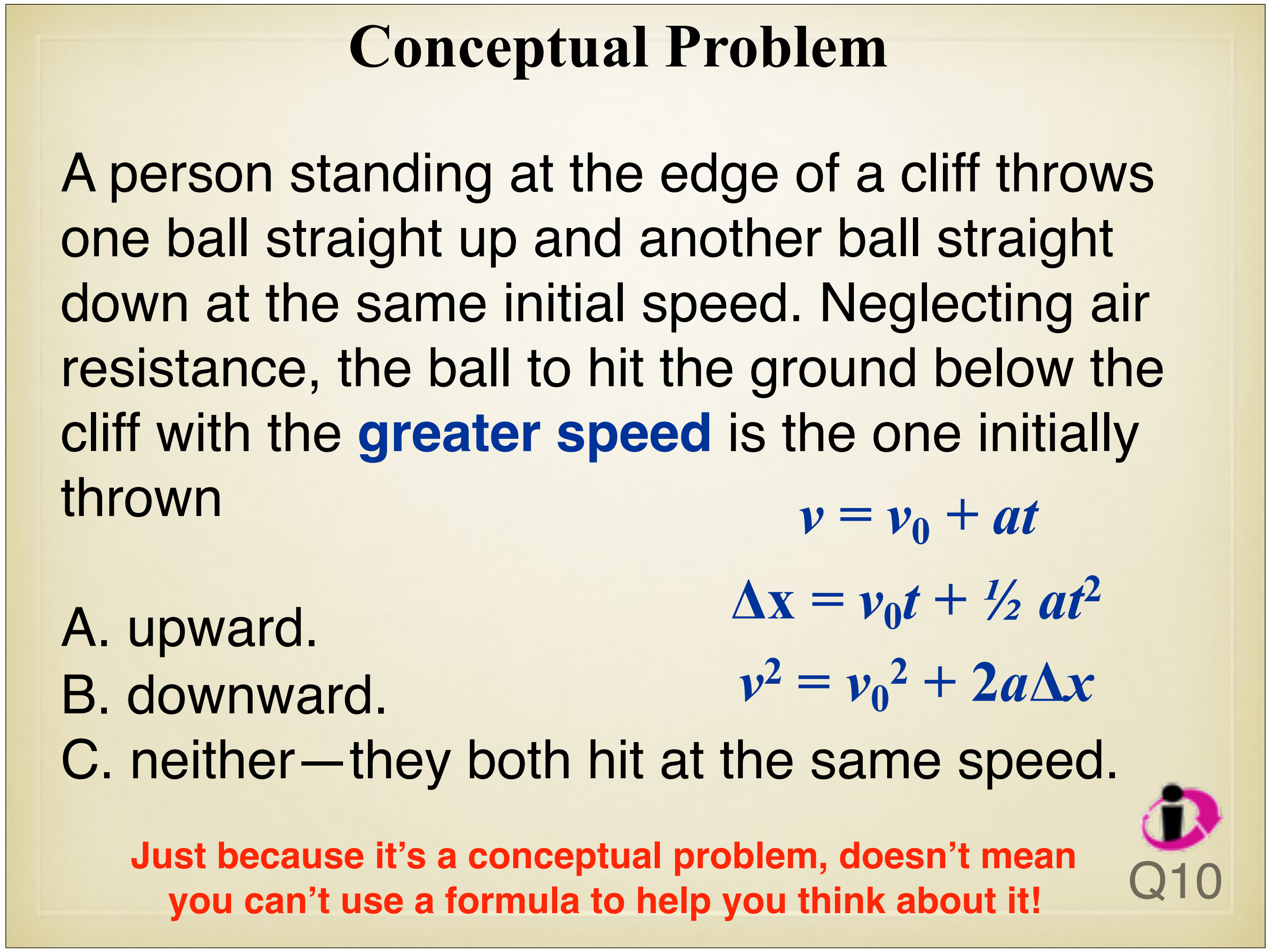
$$v^2 = v_0^2 + 2a\Delta x$$

A. upward.
B. downward.
C. neither—they both hit at the same speed.

Q10

Answer: C. Upon its descent, the velocity of an object thrown straight up with an initial velocity *v* is exactly –*v* when it passes the point at which it was first released.

You'll notice these equations keep showing up. You can bet they'll be on the test!!!



Conceptual Problem

A person standing at the edge of a cliff throws one ball straight up and another ball straight down at the same initial speed. Neglecting air resistance, the ball to hit the ground below the cliff with the **greater speed** is the one initially thrown

$$v = v_0 + at$$

$$\Delta x = v_0 t + ½ at^2$$

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

A. upward.
B. downward.
C. neither—they both hit at the same speed.

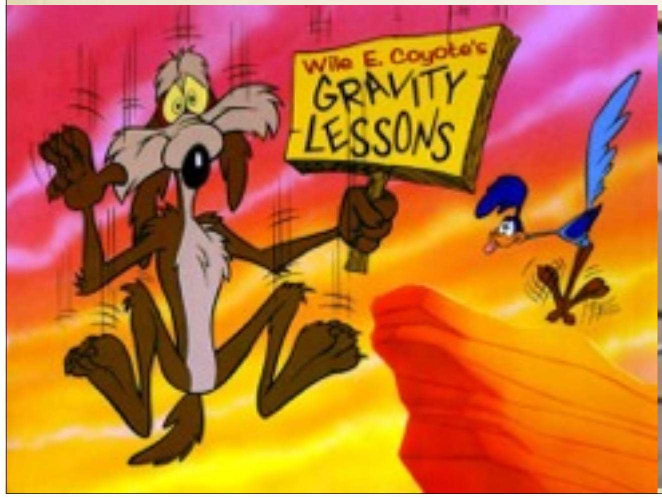
Just because it's a conceptual problem, doesn't mean you can't use a formula to help you think about it!

Q10

Answer: C. Upon its descent, the velocity of an object thrown straight up with an initial velocity *v* is exactly –*v* when it passes the point at which it was first released.

You'll notice these equations keep showing up. You can bet they'll be on the test!!!

Injury from Falling and/or a Collision



When we hit a wall or the ground, acceleration is, for a brief period, in the opposite direction and much larger than our initial acceleration and velocity vectors.

Injury from Falling and/or a Collision

- It’s not the falling that hurts, but the *stopping*.
- Skydiving at $a = 9.8\ \mathrm{m/s^2}$ is (more or less) healthy.
- When we stop, a is much more than $9.8\ \mathrm{m/s^2}$
- How do treat a problem with 2 accelerations?

When we hit a wall or the ground, acceleration is, for a brief period, in the opposite direction and much larger than our initial acceleration and velocity vectors.

I assigned you a homework problem that I think is important for a lot of your careers and lives, especially the medical folks.
It might be a tad tricky so I wanted to set it up for you so you understand it.
PADDED HELMETS not only stop your skull from cracking, but also ease the acceleration.

Large acceleration causes traumatic brain injury.

I assigned you a homework problem that I think is important for a lot of your careers and lives, especially the medical folks.
It might be a tad tricky so I wanted to set it up for you so you understand it.
PADDED HELMETS not only stop your skull from cracking, but also ease the acceleration.

Large acceleration causes traumatic brain injury.

http://www.ncbi.nlm.nih.gov/pmc/articles/PMC155415/

Generally, an acceleration less than 800 m/s^2 lasting for any length of time will not cause injury, whereas an acceleration greater than 1000 m/s^2 lasting for at least 0.001 seconds will cause injury.

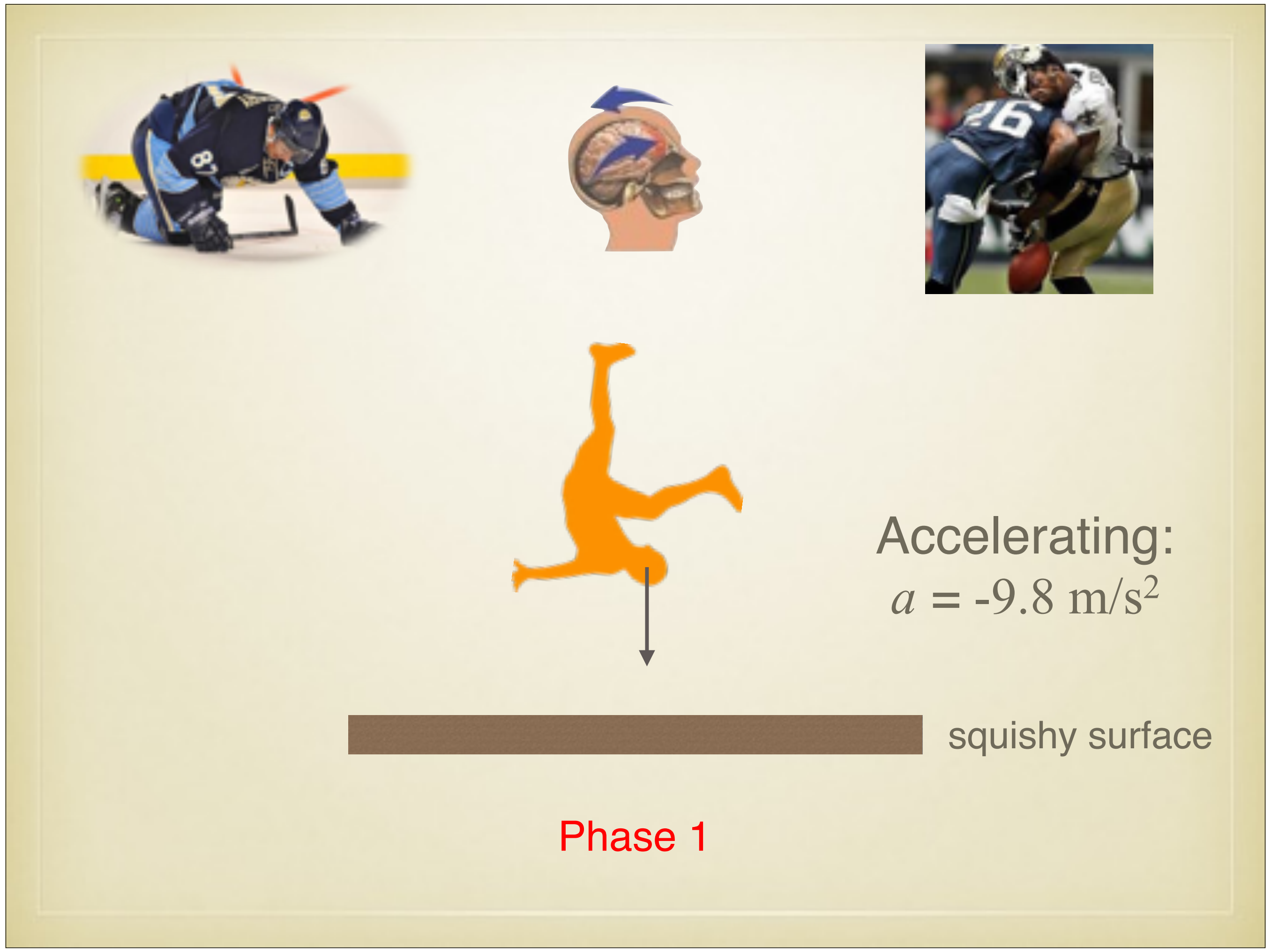
I assigned you a homework problem that I think is important for a lot of your careers and lives, especially the medical folks.
It might be a tad tricky so I wanted to set it up for you so you understand it.
PADDED HELMETS not only stop your skull from cracking, but also ease the acceleration.

Accelerating:

$a = -9.8\ \mathrm{m/s^2}$

squishy surface

First phase, he’s in free fall.



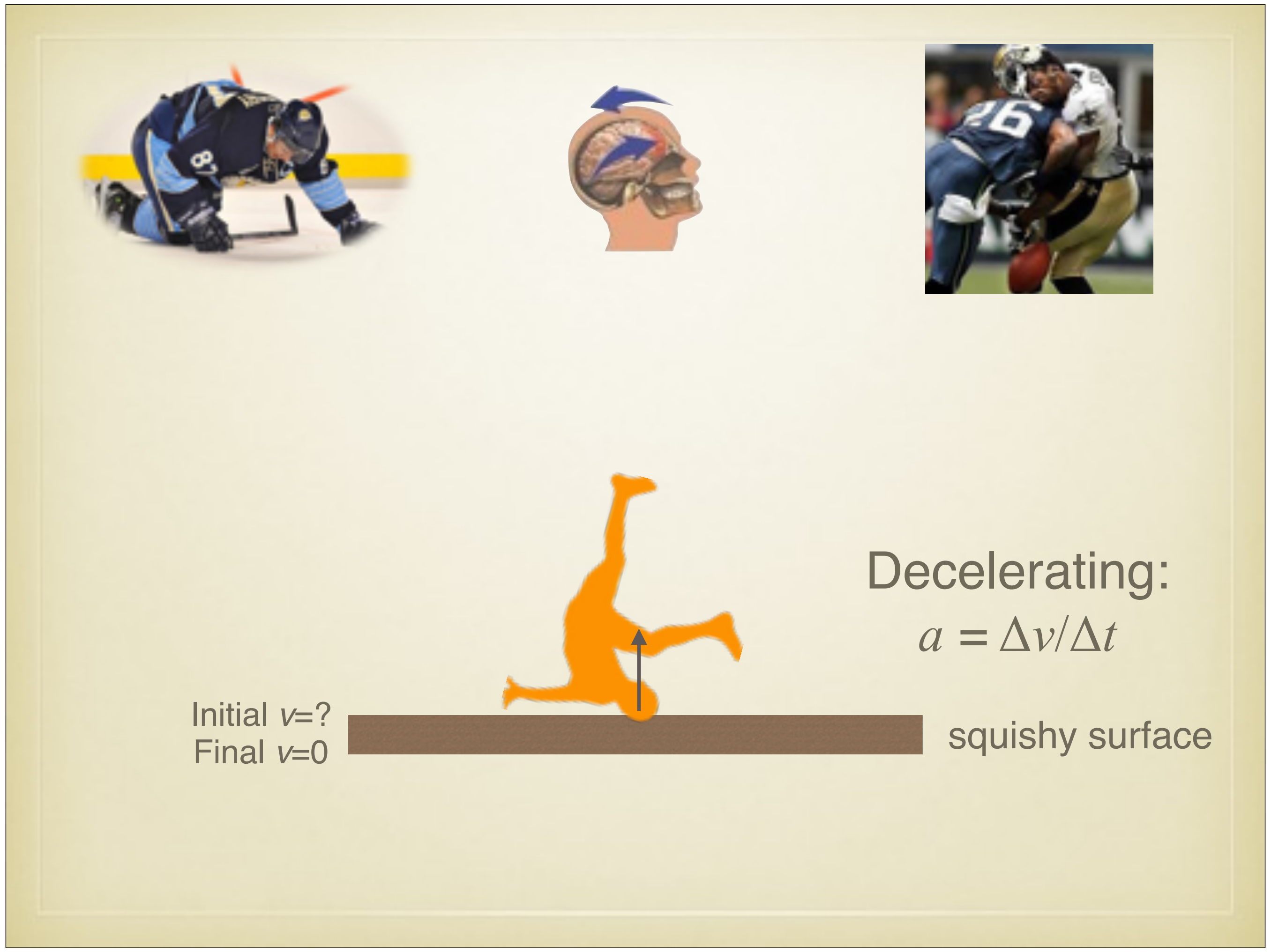
Accelerating:

$a = -9.8\ \text{m/s}^2$

squishy surface

Phase 1

First phase, he’s in free fall.



Decelerating:

$a = \Delta v / \Delta t$

Initial v=?
Final v=0

squishy surface

As soon as he hits the surface, he’s no longer in free-fall. He’s going from an initial velocity to a final velocity in a brief period of time.

Decelerating:

$a = \Delta v/\Delta t$

Initial v=?

Final v=0

squishy surface

Phase 2:

Coming to rest over a given duration and distance

As soon as he hits the surface, he’s no longer in free-fall. He’s going from an initial velocity to a final velocity in a brief period of time.