Main Ideas in Class Today

- Introduction to Falling
- Apply Old Equations
- Graphing Free Fall
- Solve Free Fall Problems

Practice: 2.45, 2.47, 2.49 (hard because two part), 2.53, 2.59, 2.61, 2.65, 2.67

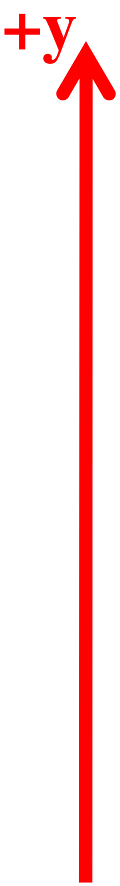
Freely Falling Objects

- Refers to objects which are not held, but are free to fall "near" the Earth's surface *(other cases Ch. 7)*
  - **All objects fall with** the same **constant acceleration** due to gravity in the absence of air resistance!

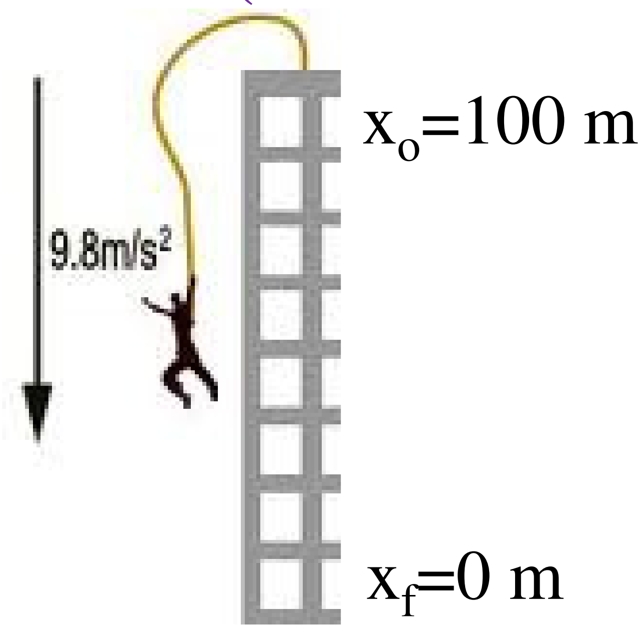
No Air on the Moon

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

Acceleration Due to Gravity



- We can often ignore air resistance, which typically has a small effect (exceptions: feathers, parachutes, big surface area/weight).
- Acceleration due to gravity points towards the ground (towards the center of Earth)
- Magnitude is g = $+9.8\ m/s^2$ near the surface of Earth
- In free fall, $a = \pm g$ depending the direction y is defined (I like to always define +y as up)



- What does that mean about the sign of acceleration, velocity and displacement?
- Thus, in this figure, *a*, *velocity* and *Δx* are all negative (what happens if I flip +y)!

$$\Delta x = x_f - x_o = 0\ m - 100\ m = -100m$$

These are the only formulas you need for Test 1 and they will be given!

besides trig

Used:

$$\bar{a} = \frac{v_f - v_i}{t_f - t_i}$$

$$\bar{v} = \frac{x_f - x_i}{t_f - t_i}$$

$$\bar{v} = \frac{v_o + v}{2}$$

Average of 2 numbers

To Get:

Only for constant acceleration

$$v = v_o + at$$

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

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

Derived in book, but you don't need to know how to derive these formulas

In free fall, the only acceleration is due to gravity: a=±g (constant)

We also generally use y instead of x (because vertical motion)

↓+y

Define y down to use a=+g

Define y up to use a= -g

↑+y

$$v = v_o - gt$$

$$\Delta y = v_o t - \tfrac{1}{2} g t^2$$

$$v^2 = v_o^2 - 2g\Delta y$$

Same formulas just different letters

A lot of confusion about physics is just due to calling the same thing by different letters

Same style as comparison questions on the practice test (additional materials)

If you toss a ball upward with a certain initial speed, it falls freely and reaches a maximum height *h*. By what factor must you increase the initial speed of the ball for it to reach a maximum height 4*h*?

$$v = v_o + at$$

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

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

A. 2

B. 3

C. 4

D. 8

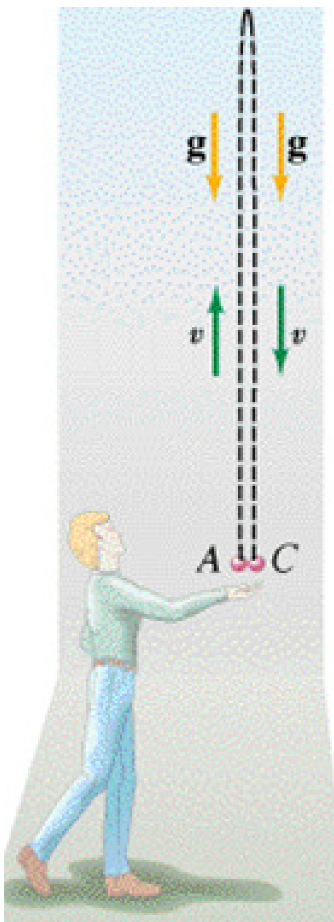
E. 16

Just because it's a conceptual problem, doesn't mean you can't use numbers.

Q10

Similar to Homework

A baseball is thrown up in the air at an initial velocity of 22.0 m/s.
(a) How high up does it go? (b) How long is it in the air if you catch it at the same height you initially let go of the ball?



$$v = v_o + at$$

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

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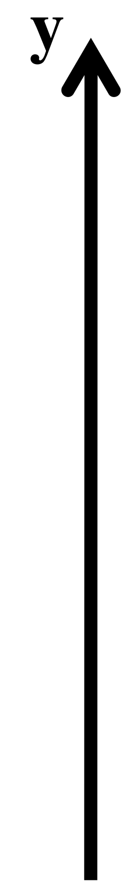
No Talking This Time!

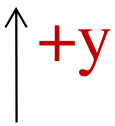


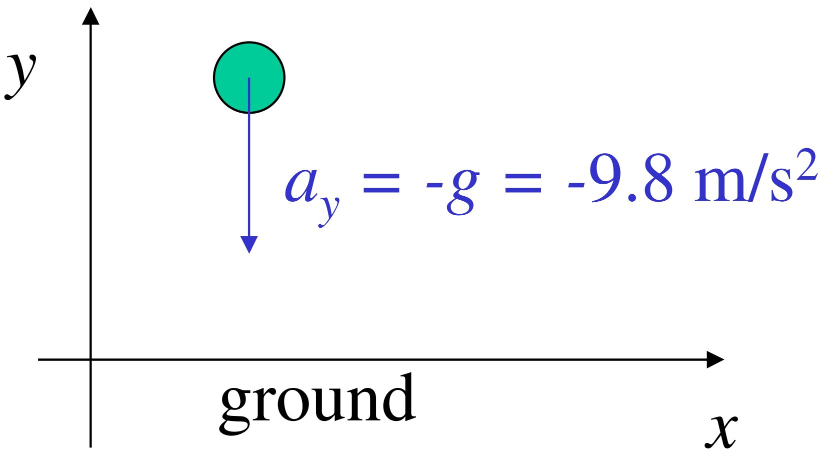
A ball is tossed straight up into the air. Which of the following represents the **sign(s)** of the **acceleration** as it moves upward, reaches its highest point, and falls back down?

	Moving upward	Highest point	Falling back down
A.	**+**	**0**	**-**
B.	**-**	**0**	**-**
C.	**-**	**-**	**-**
D.	***None of these***		

Q11

Graphing Freely Falling Bodies



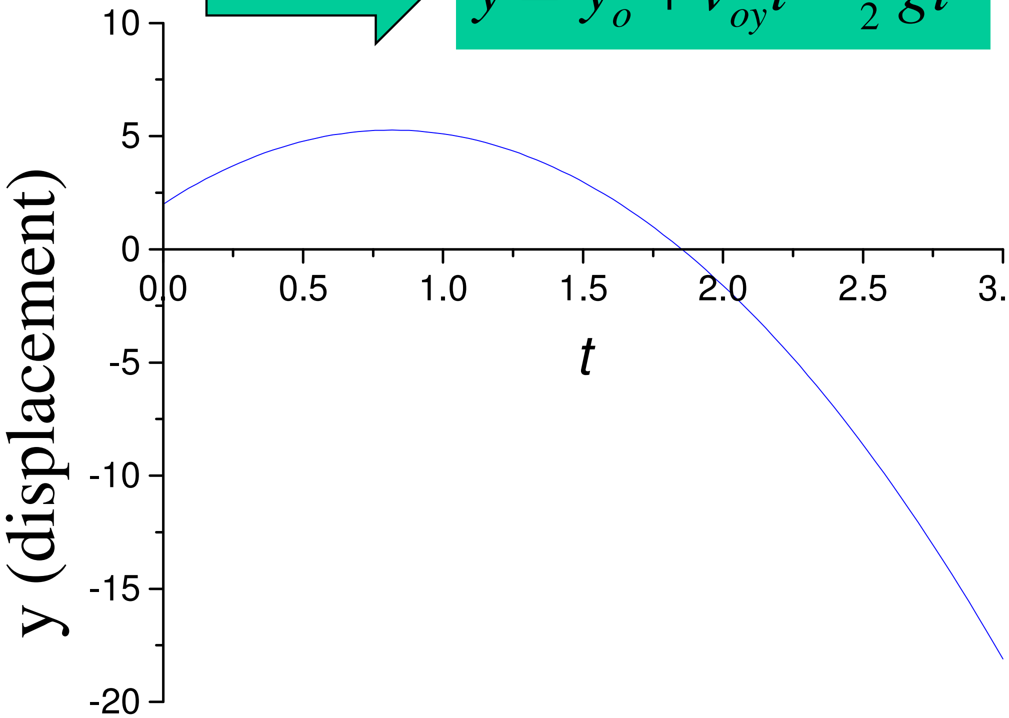


Equation of a straight line

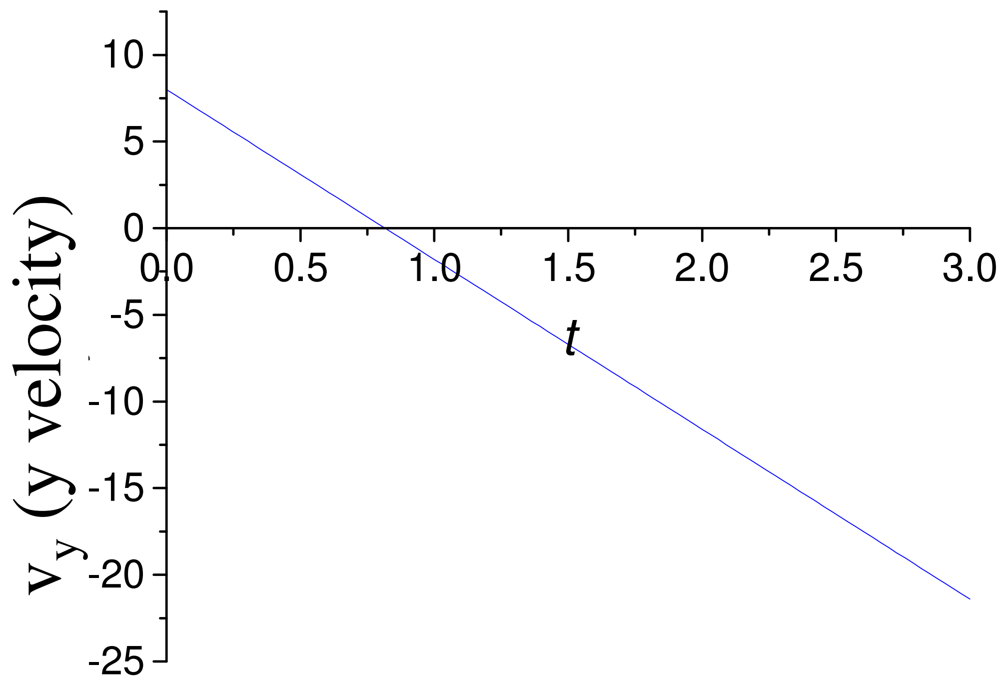
$$y = mx + b$$

m is slope, b is y-intercept

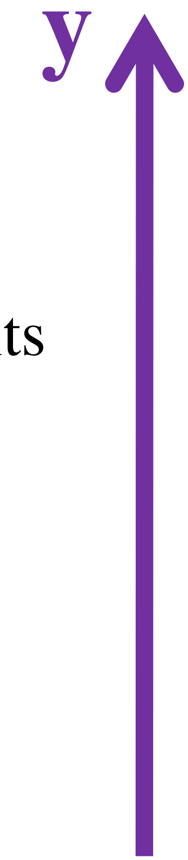
$$y = y_o + v_{oy}t - \tfrac{1}{2}gt^2$$



$$v_y = v_{oy} - gt$$



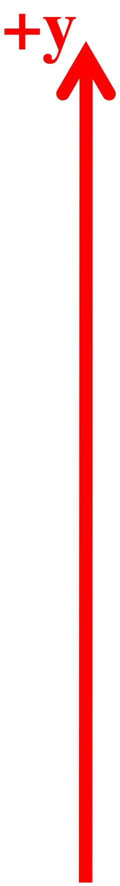
You May Talk This Time



A ball is tossed straight up into the air. Which of the following represents the **sign(s)** of the **acceleration** as it moves upward, reaches its highest point, and falls back down?

	Moving upward	Highest point	Falling back down
A.	**+**	**0**	**-**
B.	**-**	**0**	**-**
C.	**-**	**-**	**-**
D.		***None of these***	

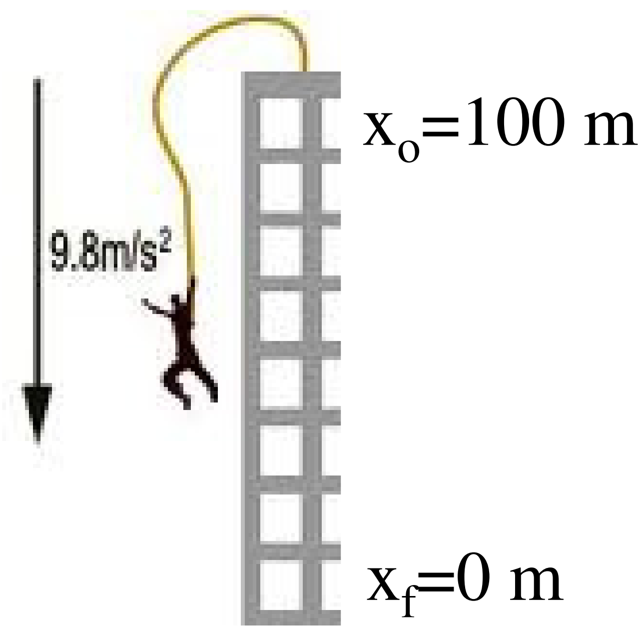
Q11



Acceleration Due to Gravity

- Acceleration due to gravity points towards the ground (towards the center of Earth)
- Magnitude is *g* = 9.8 m/s^2 near the surface of Earth
- In free fall, $a = \pm g$ depending the direction y is defined

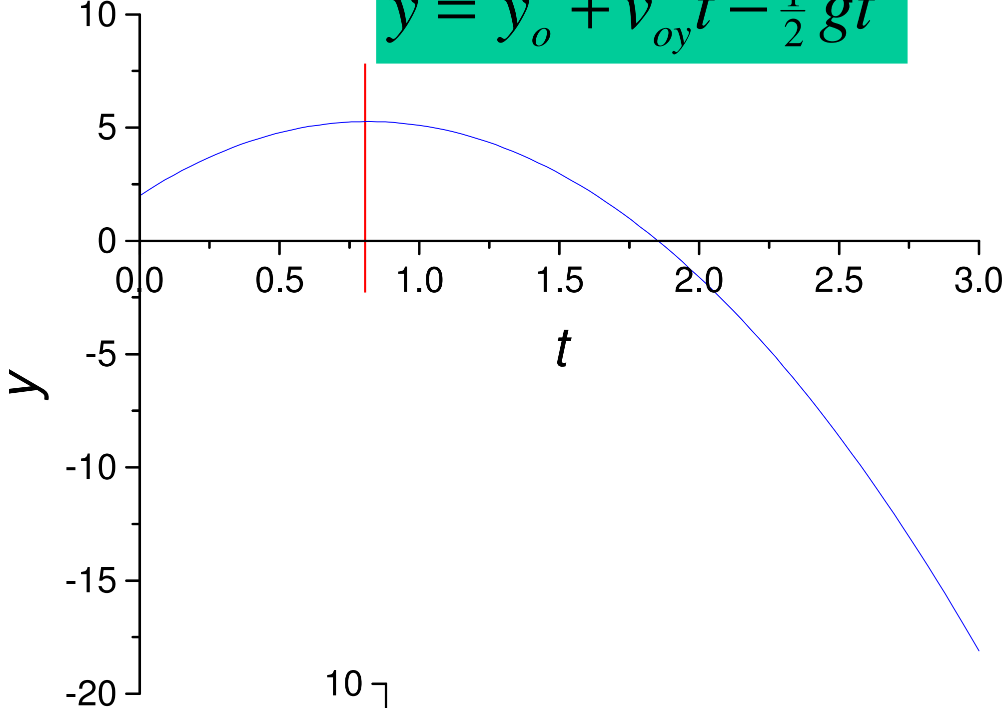
NOT ON WHICH DIRECTION YOU ARE GOING!



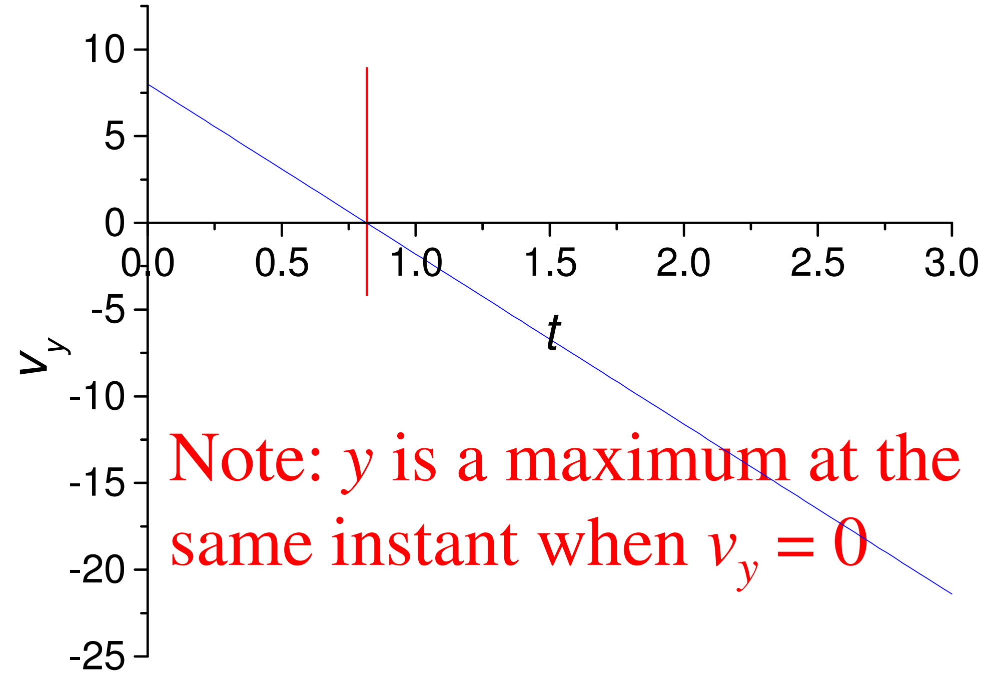
Common misconception that object stops at top of path

(only looks that way because it slows down before turning)

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

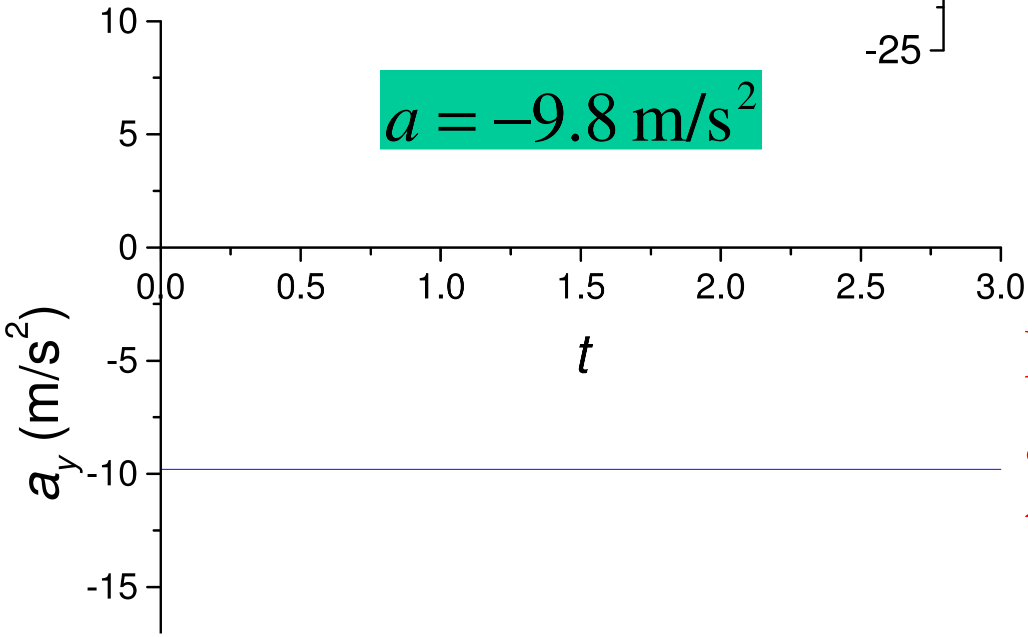


$$v_y = v_{oy} - gt$$



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

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



Note: a_y = -9.8 m/s^2 always, even at top of the trajectory!

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, 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.

Q12

A small bag is released from a helicopter that is descending steadily at 1.50 m/s.

(a) After 4.00 s, what is the speed of the bag?

(b) At 4 s, how far is it below where it was when it was dropped?

(c) What are your answers to parts (a) and (b) if the helicopter is rising steadily at 1.50 m/s? Notice that a change of the sign of velocity affects the answer!

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

$$v = v_o + at$$

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

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

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.

Q13

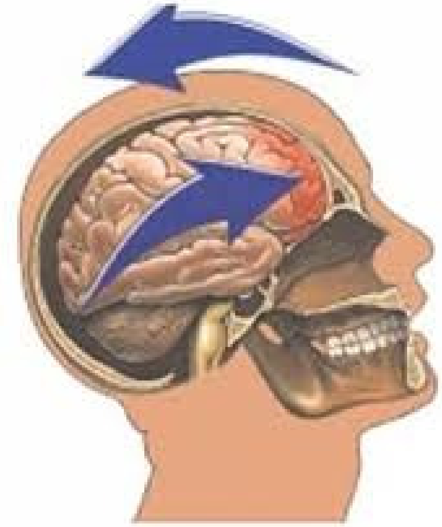
If we don’t have time for all of these problems (which is unlikely), they are possible problems if no one has other questions for the next problem solving day

Injury from Falling and/or a Collision

- It's not the falling that hurts, but the stopping
- Skydiving at $a=9.8\ m/s^2$ is fine
- When we stop, a is much more than $9.8\ m/s^2$
- How do treat a problem with 2 accelerations?

Concussions: The Gravity of It All

Pun intended ☺



Traumatic brain injury results when the head undergoes a very large acceleration.

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.

So what do we need to know in order to get time and acceleration?

Challenging Application: Child Falling from Bed

Suppose a child rolls off a bed that is 1.0 m above the floor. If the floor is hardwood, the child's head is brought to rest in ~ 2.0 mm (carpet ~ 1.0 cm, 5x more). Calculate the magnitude (and duration) of the acceleration for hardwood to determine the risk of injury.

Why is this a challenging problem?

Figuring Out Which Formula

(main formulas given on exam, see website)

$$\bar{v} \equiv \frac{x_f - x_i}{t_f - t_i} = \frac{\Delta x}{\Delta t}$$

Eq. A

$$x = x_o + v_o t + \tfrac{1}{2} a t^2$$

Eq. B

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

Eq. C

$$v = v_o + at$$

Eq. D

List your knowns and unknowns:

- constant velocity
- Δx, v_o, v, a
- v_o, v, a, t
- Same strategy applies to multipart questions, you just do one part at a time. Sometimes need answer from a to answer b

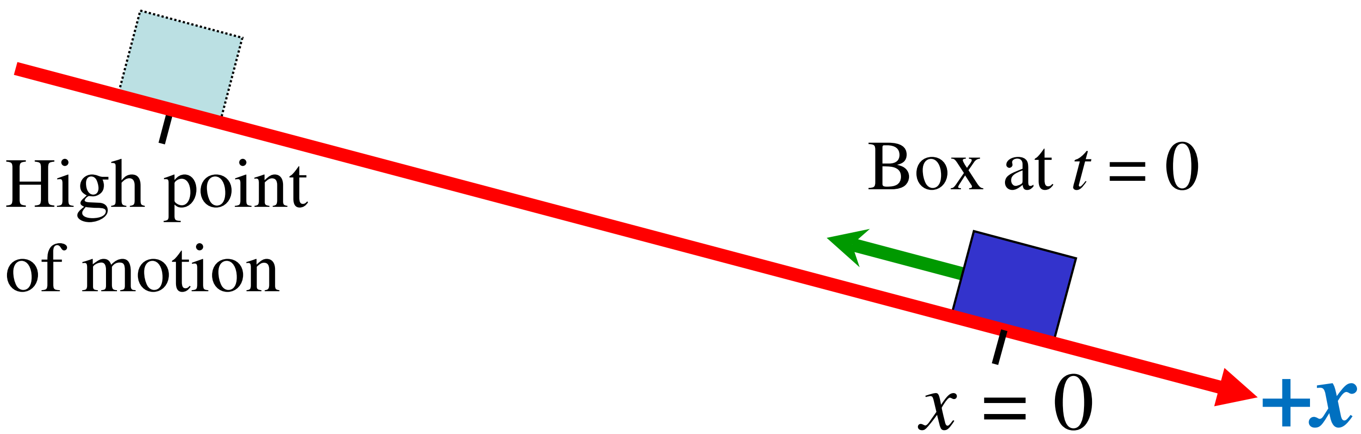
Sometimes easier to find which formula does not have the variable you are NOT considering

Q14

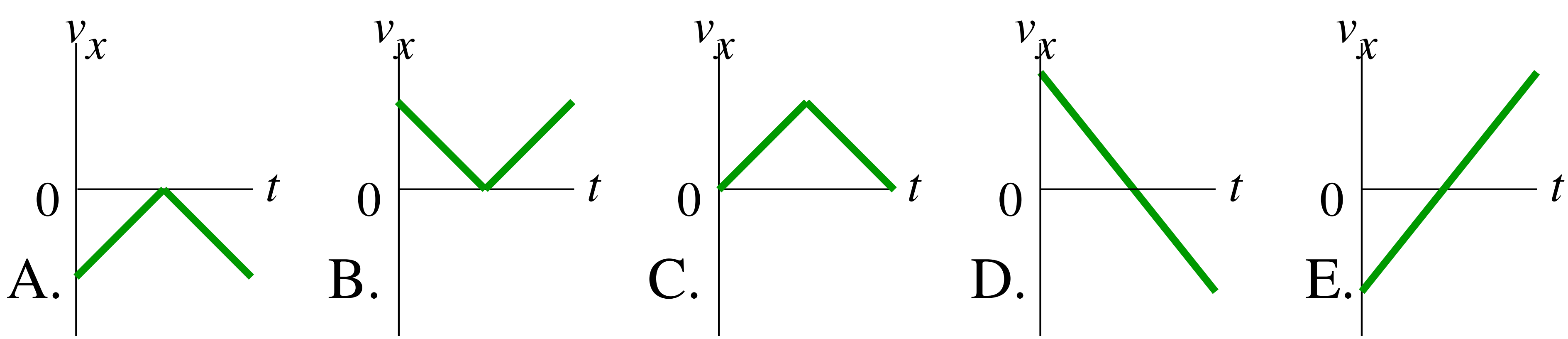
The next two are harder, talk to neighbors

A box is on an inclined, frictionless track. The *positive x direction* points downhill. At $t = 0$ the box is at $x = 0$ and moving uphill.

After reaching the high point of its motion, it moves downhill and returns to $x = 0$.



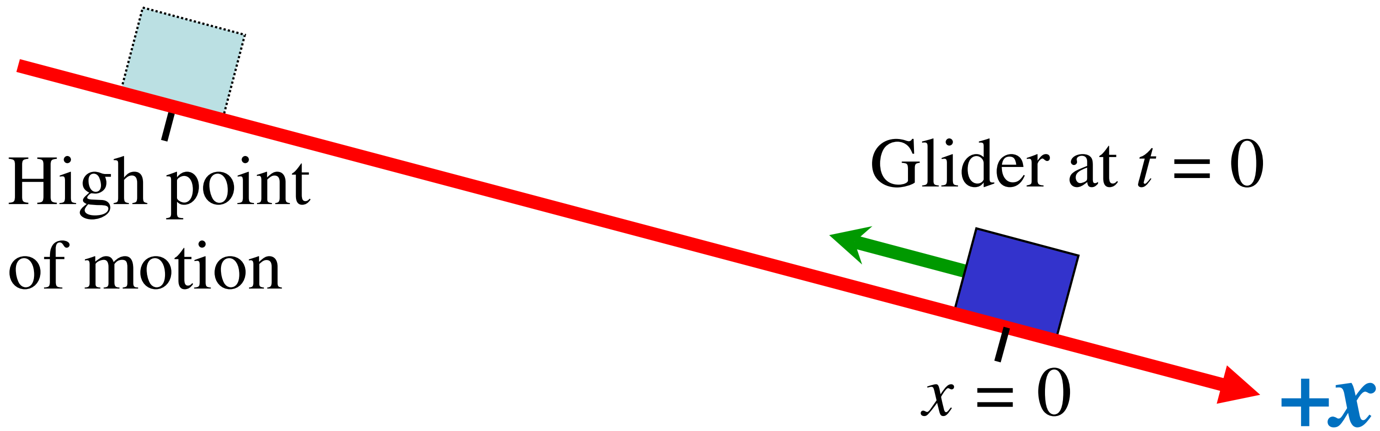
Which of the following graphs of velocity versus time best matches the motion of the box?



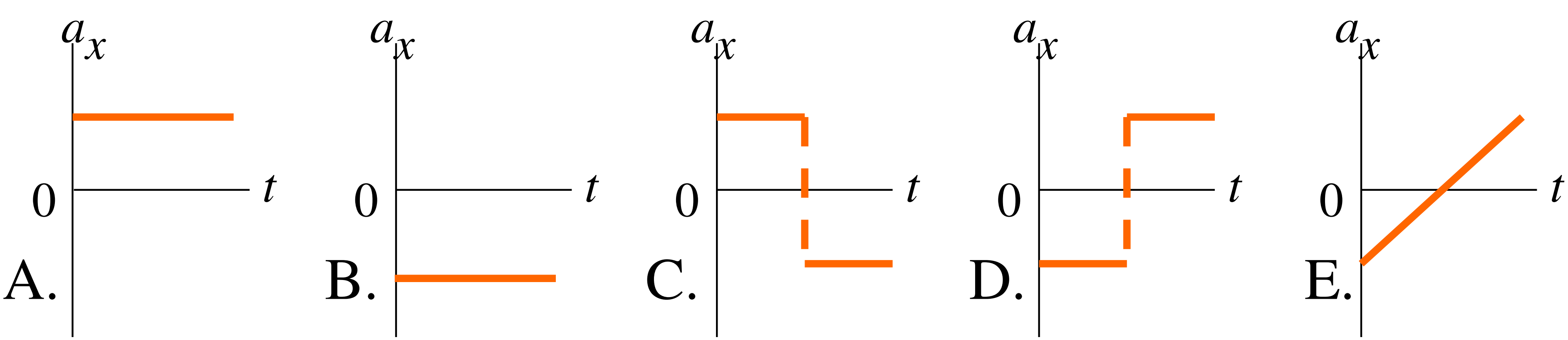
Q15

A box is on an inclined, frictionless track. The x-axis points downhill. At $t = 0$ the box is at $x = 0$ and moving uphill.

After reaching the high point of its motion, it moves downhill and returns to $x = 0$.



Which of the following a_x–t graphs (graphs of acceleration vs. time) best matches the motion of the box?



10a, 11c, 12b, 13c, 14e, 15a