College Physics I: 1511 Mechanics & Thermodynamics

Professor Jasper Halekas
Van Allen Lecture Room 1
MWF 8:30-9:20 Lecture

Announcements

- Labs and discussion sections both start this week!
  - Be sure to fill out your pre-lab questions before going to lab

Kinematics Equations

$$v_f = v_o + at$$

$$x_f = x_o + v_o t + \tfrac{1}{2}at^2$$

$$v_f^2 = v_o^2 + 2a(x_f - x_o)$$

$$x_f = x_o + \tfrac{1}{2}(v_f + v_o)t$$

$$v_f = v_0 + at$$

from definition of

$$a = \frac{v_f - v_0}{t}$$

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

from definition

$$\langle v \rangle = \frac{x_f - x_0}{t}$$

$$x = x_0 + v_0 t + \tfrac{1}{2} a t^2$$

– combines these two equations to make a full equation of motion

$$V_f = V_0 + at$$
$$\Rightarrow V_f - V_0 = at$$
$$\Rightarrow t = (V_f - V_0)/a$$

$$X_f = X_0 + V_0 t + \tfrac{1}{2} a t^2$$
$$X_f = X_0 + V_0 (V_f - V_0)/a + \tfrac{1}{2} a \left(\frac{V_f - V_0}{a}\right)^2$$
$$= X_0 + \frac{V_0 V_f}{a} - \frac{V_0^2}{a} + \tfrac{1}{2} V_f^2/a - \frac{V_f V_0}{a} + \tfrac{1}{2} V_0^2/a$$
$$= X_0 + (V_f^2 - V_0^2)/2a$$
$$2a X_f = 2a X_0 + V_f^2 - V_0^2$$

$$\Rightarrow V_f^2 = V_0^2 + 2a(X_f - X_0)$$

- very useful if you don't know how long something took

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e.g. a truck accelerates at $4\ m/s^2$ along a 1 km stretch of road. How fast does it end up going?

$$V_f^2 = 0 + 2 \cdot 4 \cdot 1000$$
$$= 8000$$

$$\Rightarrow V_f = \sqrt{8000}\ m/s$$
$$\cong 90\ m/s$$

A truck traveling 100 m/s brakes w/ acceleration of $-1\ m/s^2$. How far does it take to stop?

$$V_f^2 = 0 = 100^2 + 2 \cdot (-1) \cdot \Delta x$$

$$= 10000 - 2\,\Delta x$$

or $10000 = 2\,\Delta x$

$$\boxed{\Delta x = 5000\,m = 5\,km}$$

How long did it take?

$$V_f = 0 = V_0 + a t$$

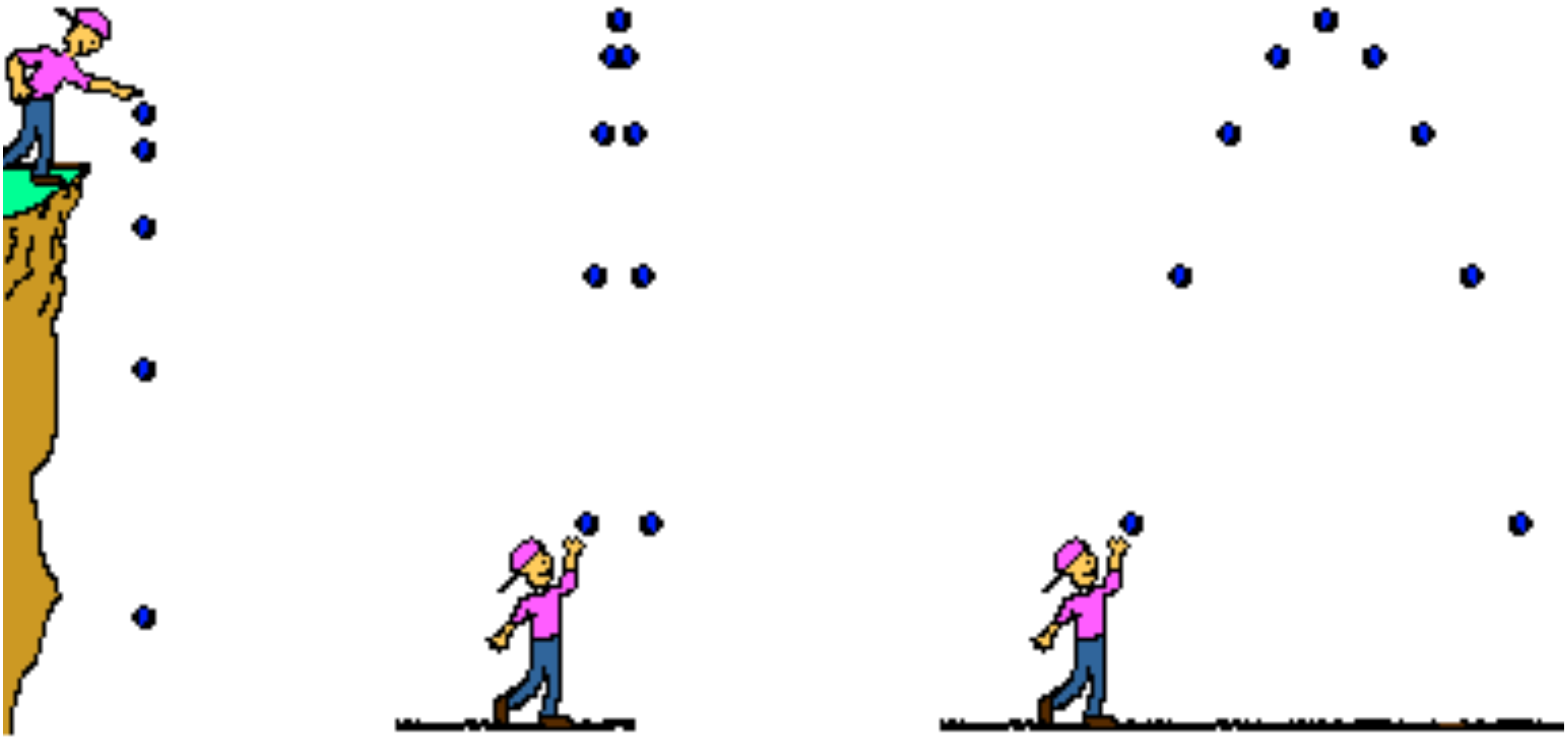
$$= 100 + (-1) \cdot t$$

or $\boxed{100\,s = t}$

Notice $\Delta x = \langle v \rangle\, t$

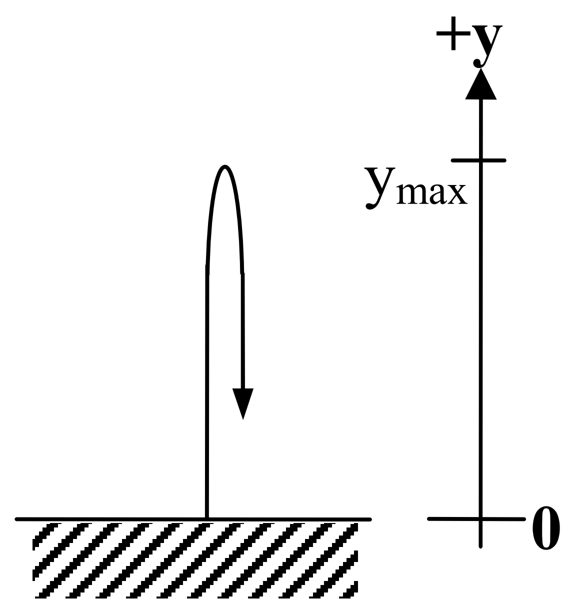
$$= (V_f + V_0)/2 \cdot t$$

Gravity

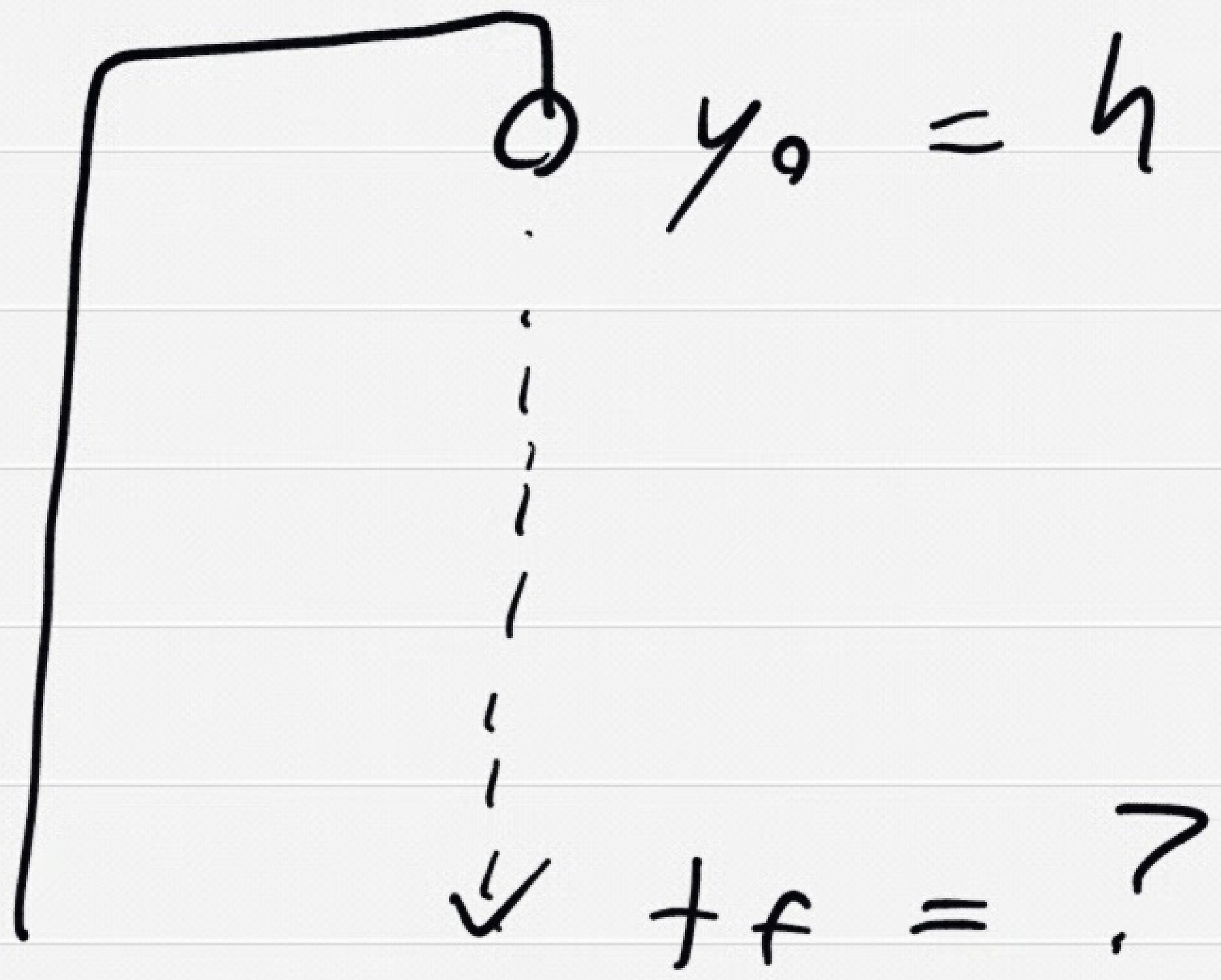


Gravity = Constant Acceleration

- Assuming a coordinate system with y-axis upward
- $a = -g = -9.8\ m/s^2$
- $y = y_o + v_{yo}t + ½\ a\ t^2$
- $y = y_o + v_{yo}t - ½\ g\ t^2$



Free fall time:



$$y_f = y_0 + v_{y0} t + \tfrac{1}{2} a t^2$$

$$y_0 = h$$
$$v_{y0} = 0$$
$$a = -g$$

$$y_f = h - \tfrac{1}{2} g t_f^2 = 0$$

$$\Rightarrow h = \tfrac{1}{2} g t_f^2$$
$$2h/g = t_f^2$$

$$\boxed{t_f = \sqrt{2h/g}}$$

Final velocity

$$v_{yf} = v_{y0} + a t_f$$
$$= -g t_f$$
$$= -g\sqrt{2h/g} = \boxed{-\sqrt{2hg}}$$

Concept Check

- Two stones are dropped into a bottomless pit, the second stone is dropped 2 seconds after the first stone. Assume no air resistance. As both stones fall, the difference in their velocities..

- A: increases
- B: decreases
- C: remains constant

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Concept Check Part Two

- As both stones fall, the difference in their heights (y-positions)..

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$$V_1 = V_{10} + a_1 t$$

$$= -gt$$

$$V_2 = -g(t+2)$$

$$= -gt - 2g$$

$$V_2 - V_1 = -2g = \text{const.}$$

$$x_1 = x_{10} + V_{10} t + \tfrac{1}{2} a_1 t^2$$

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

$$x_2 = -\tfrac{1}{2} g (t+2)^2$$

$$= -\tfrac{1}{2} g (t^2 + 2t + 4)$$

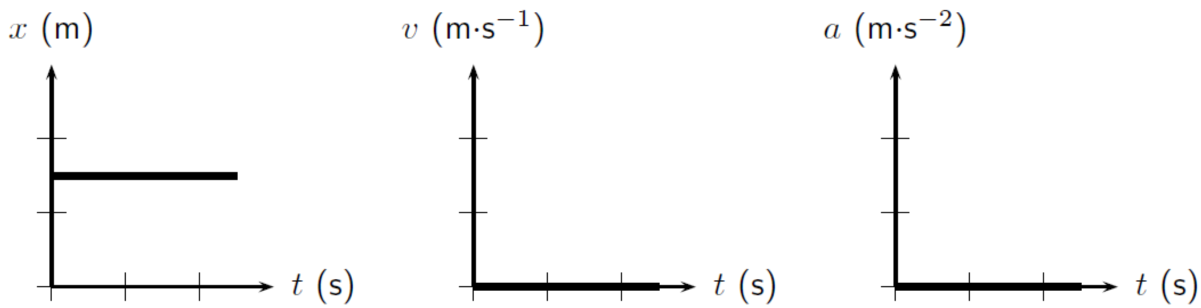
$$x_2 - x_1 = -\tfrac{1}{2} g (2t + 4)$$

not constant

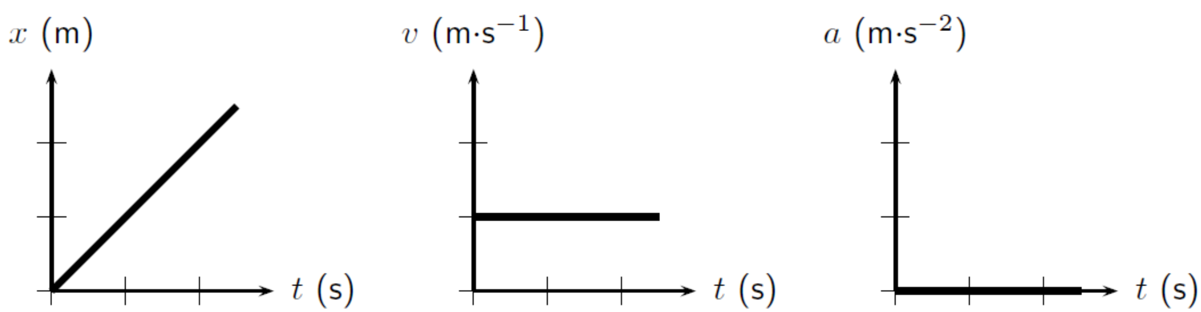
If velocity different, displacement must change at different rates!!

Graphing Motion

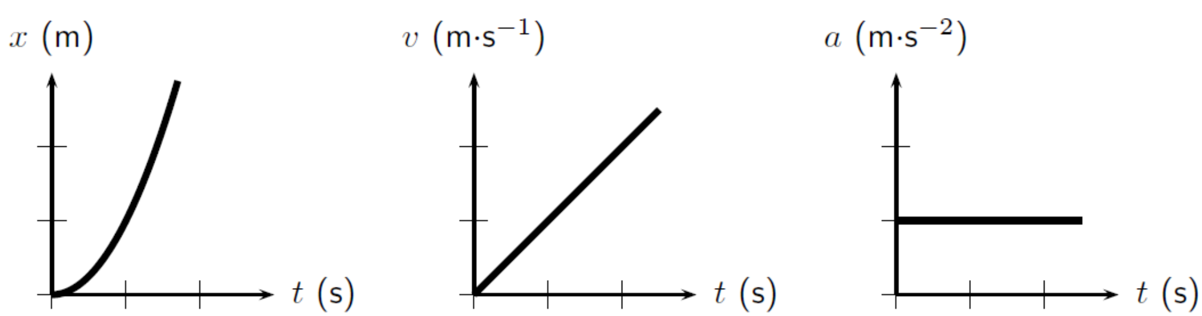
Stationary Object



Uniform Motion

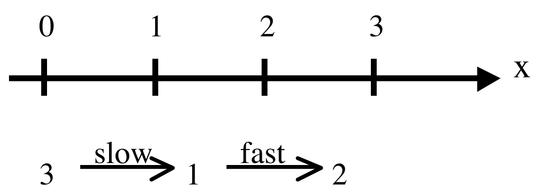


Motion with constant acceleration

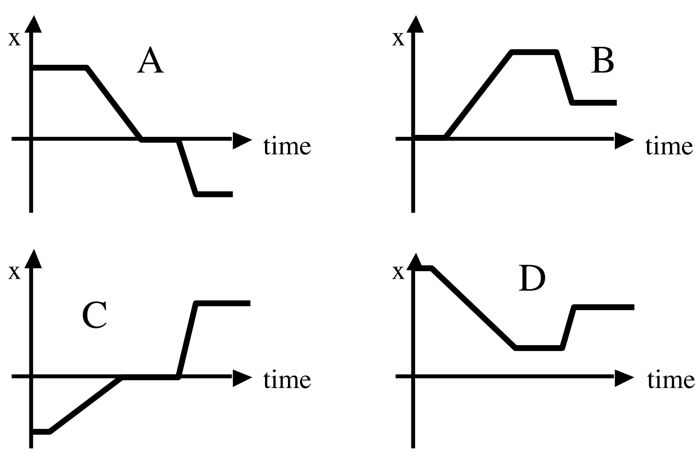


Concept Check

2-7 A person initially at x = 3 on the x-axis stays there for a while and then strolls along the x-axis to x = 1, stays there for a bit and then runs to x = 2 and remains there.



Which of the following graphs depicts this motion?



E: None of these!

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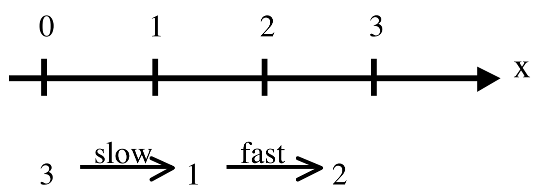

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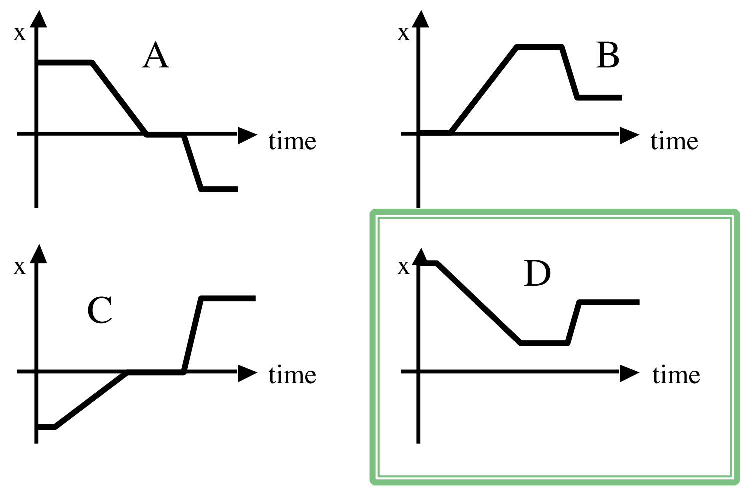
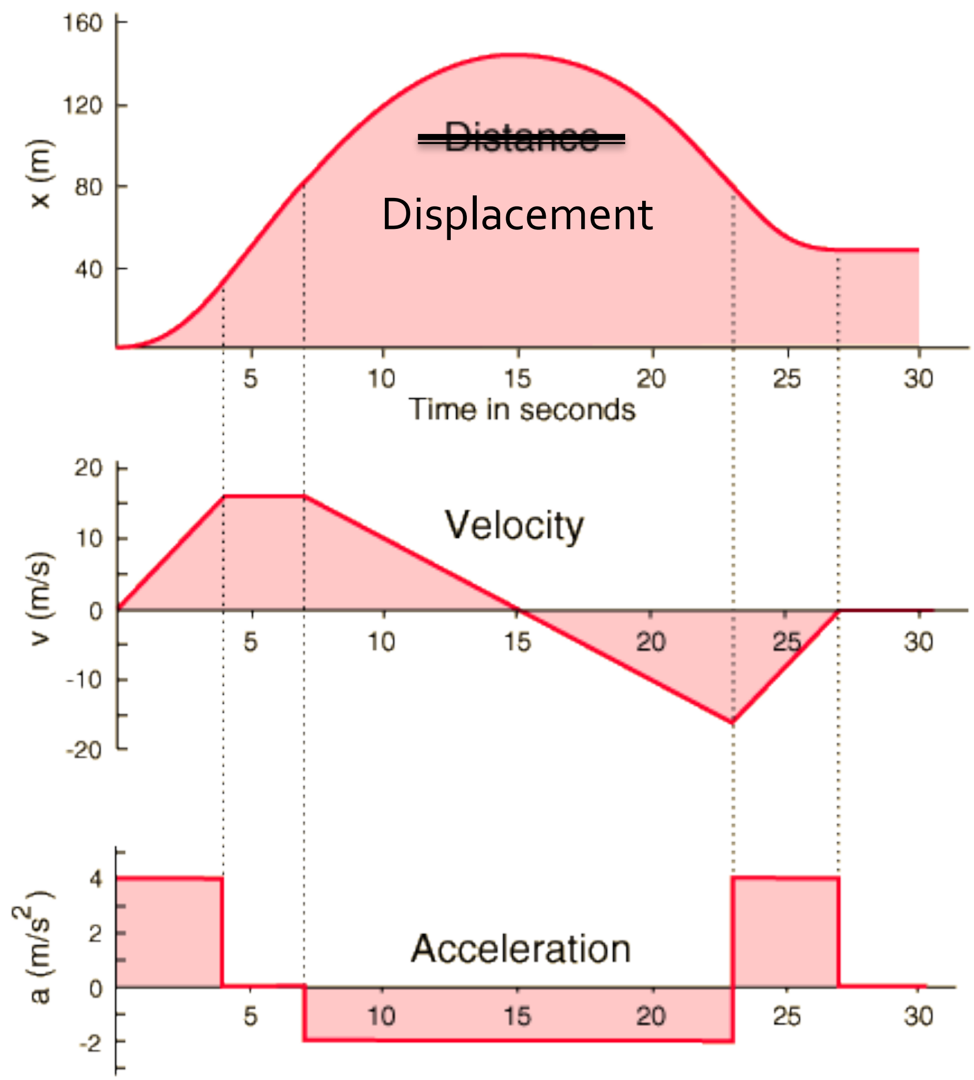
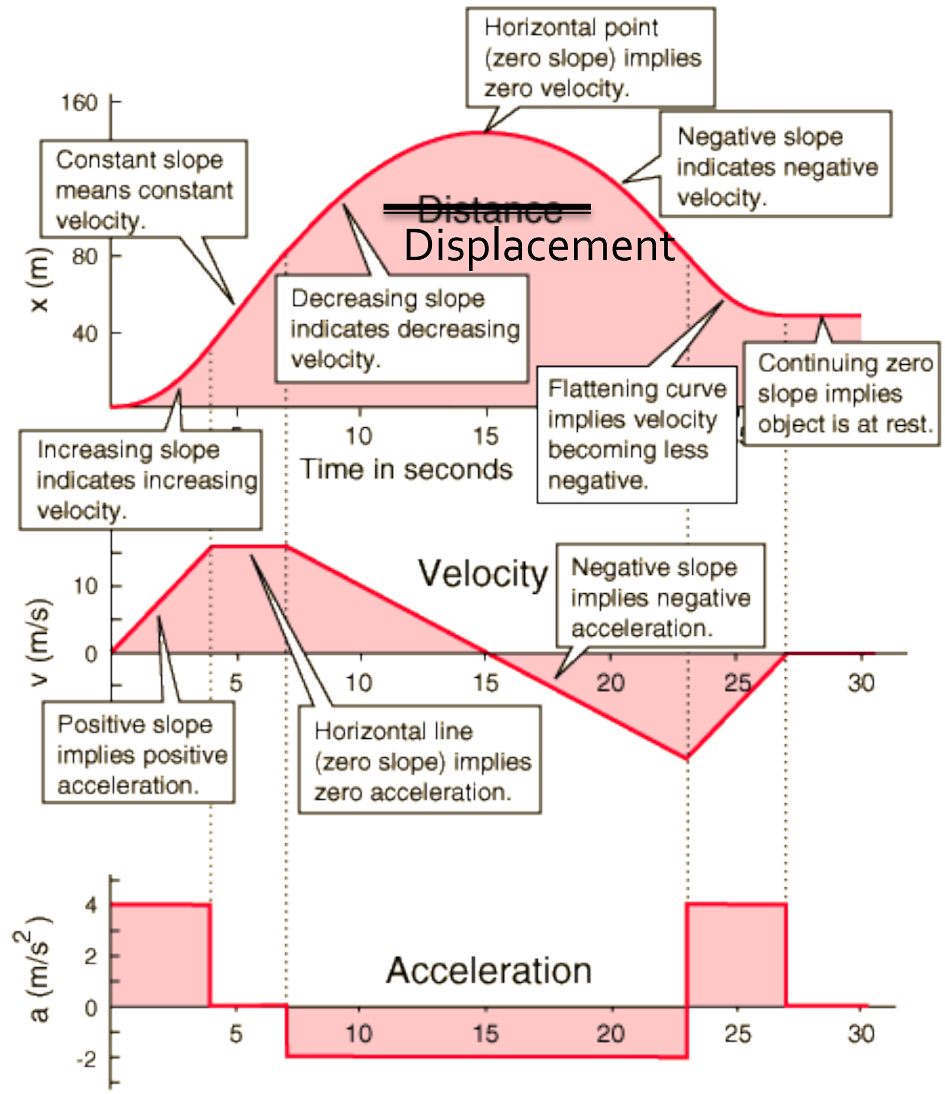


E: None of these!

Graphical Analysis: More Complex



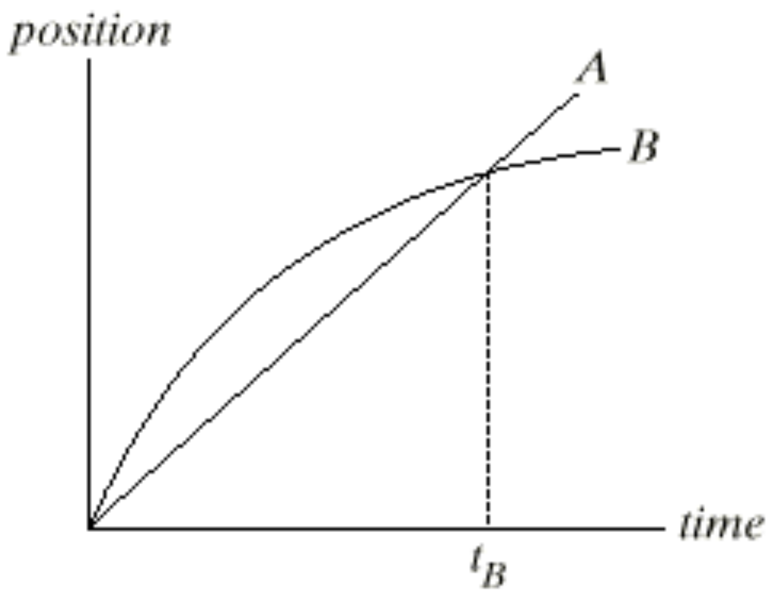
Graphical Analysis: Information



Concept Check

The graph shows position as a function of time for two trains running on parallel tracks. Which is true:

A: At time t_B , both trains have the same velocity.
B: Both trains speed up all the time.
C: Both trains have the same velocity at some time before t_B .
D: Somewhere on the graph, both trains have the same acceleration.



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