

Constant Acceleration



When is **a** constant?

1. Freely Falling object:

$$|\mathbf{a}| = g = 9.80 \text{ m s}^{-2}$$

2. It is known/assumed/approximated to be constant.

Provides us w/ simple expression for $x(t)$, $v(t)$



How fast is a jet accelerating to stop in 2.0 sec when initially traveling at 140 mph (63 m/sec)?

Which diagram would you find most helpful for solving this?

- A. Position vs. t
- B. Velocity vs. t
- C. Acceleration vs. t
- D. Stroboscopic

$$v_i = 63 \text{ m/s}$$

$$v_f = 0$$



$$x_i = 0$$

$$x_f = ?$$

$$t_i = 0$$

$$t_f = 2 \text{ s}$$

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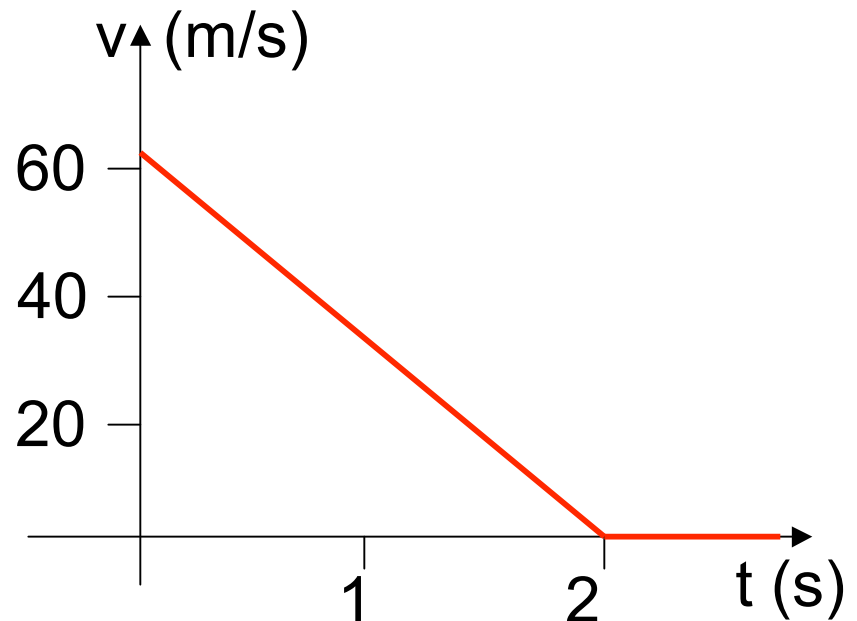
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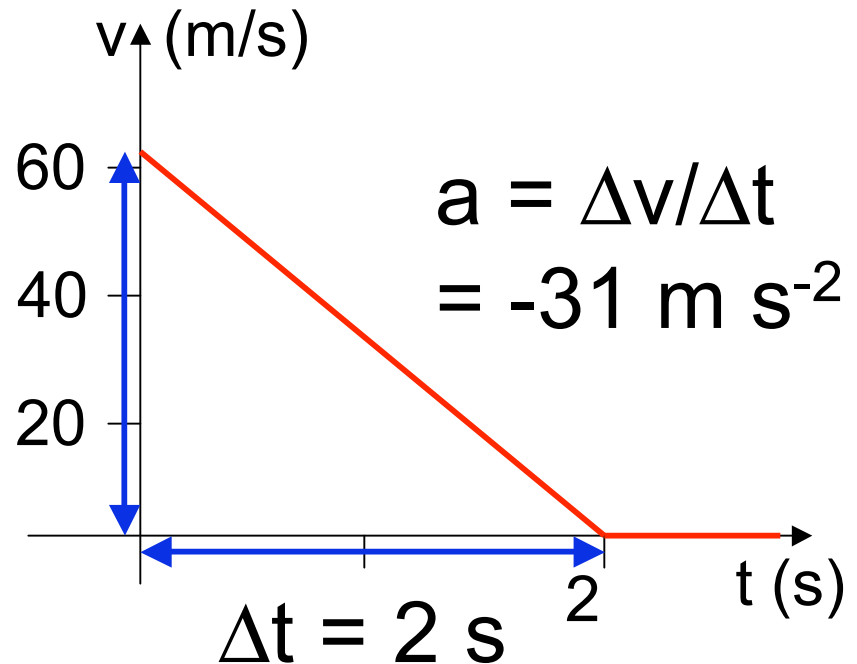
A. Position vs. t

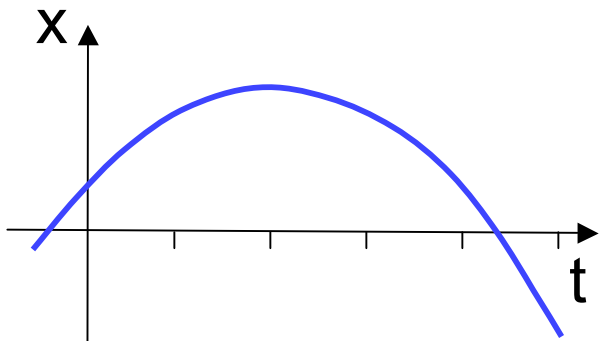
B. Velocity vs. t

C. Acceleration

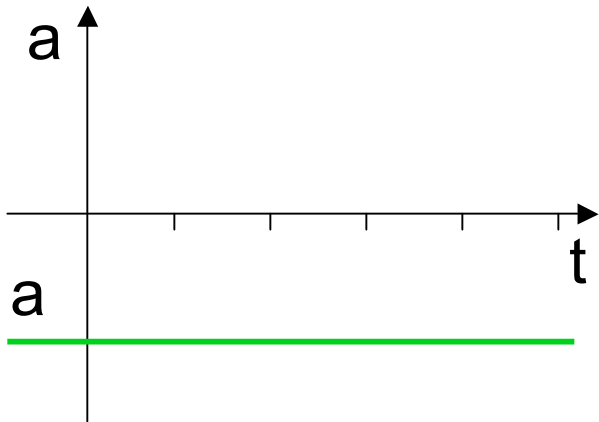
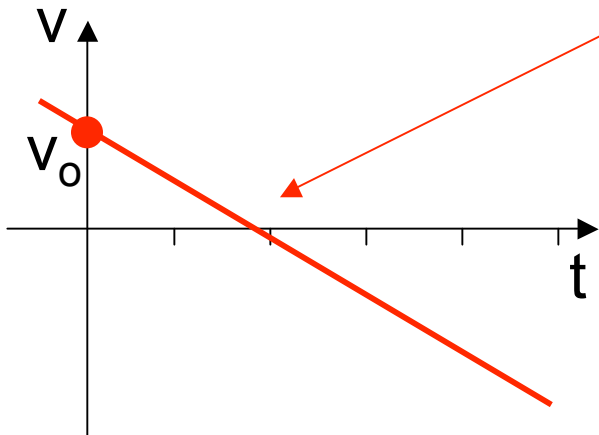
D. Stroboscopic

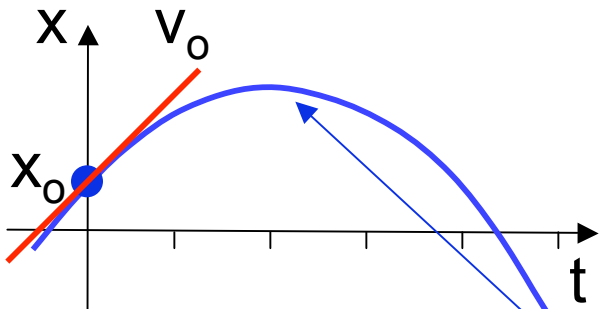
$$\Delta v = -63 \text{ m/s}$$





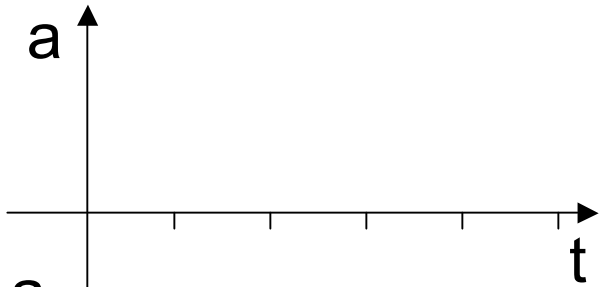
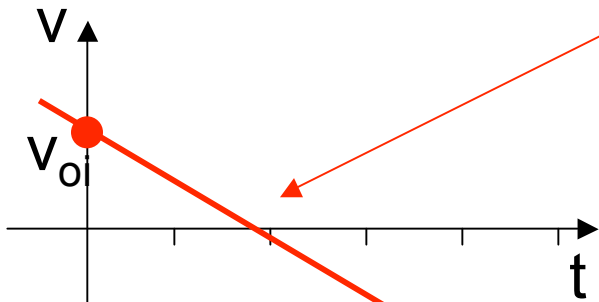
$$v = v_0 + at$$





$$v = v_0 + at$$

$$x - x_0 = v_0t + \frac{1}{2}at^2$$



$$v = v_0 + at$$

$$x - x_0 = v_0 t + \frac{1}{2}at^2$$

Eliminate t

$$v^2 = v_0^2 + 2a(x - x_0)$$

$$x - x_0 = \frac{1}{2}(v_0 + v)t$$

$$x - x_0 = vt - \frac{1}{2}at^2$$

$$v = v_0 + at$$

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Eliminate v_0

$$x - x_0 = vt - \frac{1}{2}at^2$$

Equations for Motion with Constant Acceleration^a

Equation Number	Equation	Missing Quantity
2-11	$v = v_0 + at$	$x - x_0$
2-15	$x - x_0 = v_0t + \frac{1}{2}at^2$	v
2-16	$v^2 = v_0^2 + 2a(x - x_0)$	t
2-17	$x - x_0 = \frac{1}{2}(v_0 + v)t$	a
2-18	$x - x_0 = vt - \frac{1}{2}at^2$	v_0

^aMake sure that the acceleration is indeed constant before using the equations in this table.



How fast is a jet accelerating to stop in 2.0 sec when initially traveling at 140 mph (63 m/sec)?

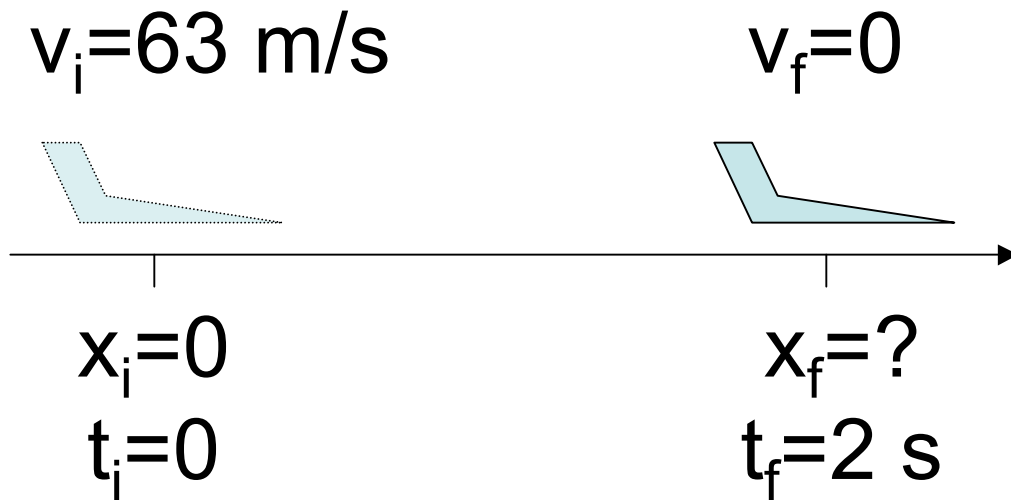
Which quantities are given?

A $x_f - x_o, v_o, t$

B $x_f - x_o, v_o, a$

C v_o, v_f, t

D v_o, v_f, a



How fast is a jet accelerating to **stop** in **2.0 sec** when initially traveling at **140 mph** (63 m/sec)?

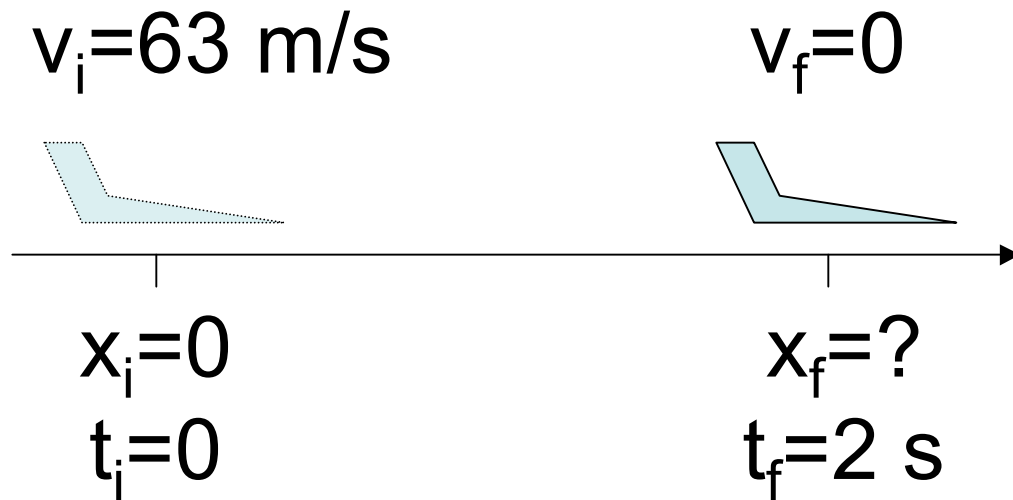
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How fast is a jet accelerating to stop in 2.0 sec when initially traveling at 140 mph (63 m/sec)?

Which Equation would you use?

A $v = v_0 + at$

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How high will a ball go if it is thrown straight upward at 15 m/s?

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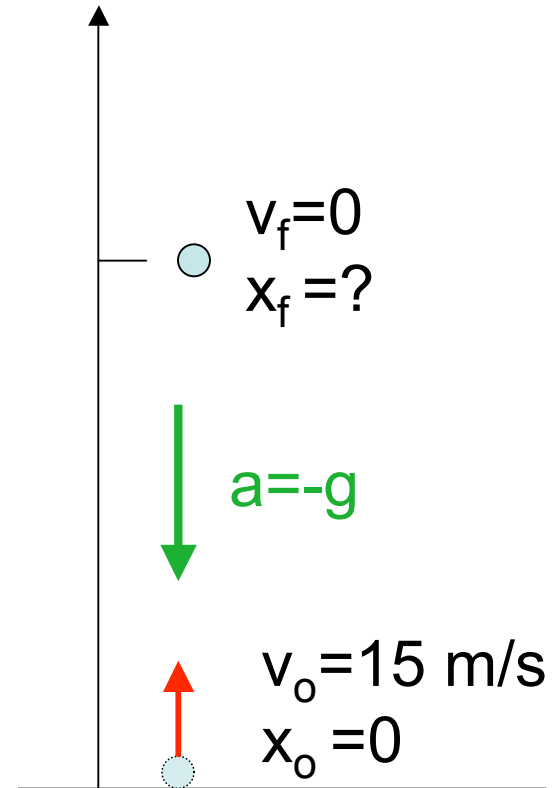
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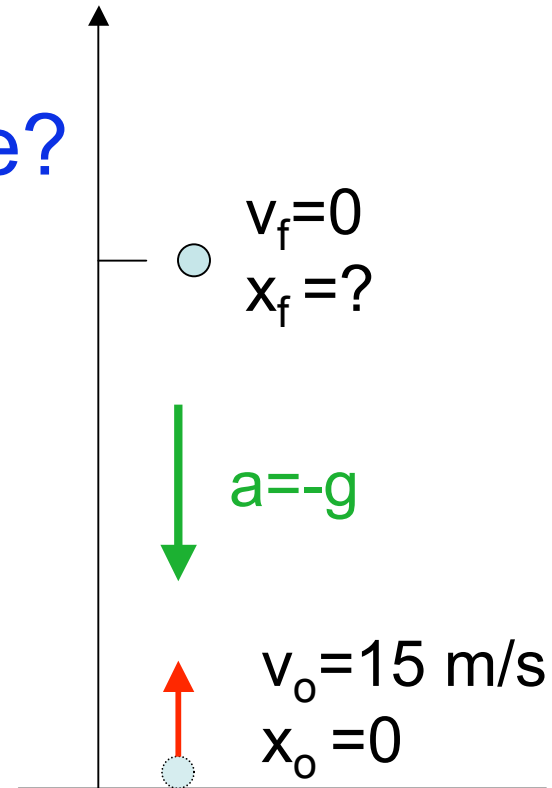
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68. At NASA's John H. Glenn research center in Cleveland, Ohio, free-fall research is performed by dropping experiment packages from the top of an evacuated shaft 145 m high. Free fall imitates the so-called microgravity environment of a satellite in orbit. (a) What is the maximum time interval for free fall if an experiment package were to fall the entire 145 m? (b) Actual NASA specifications allow for a 5.18-s drop time interval. How far do the packages drop and (c) what is their speed at 5.18 s? (d) What constant acceleration would be required to stop an experiment

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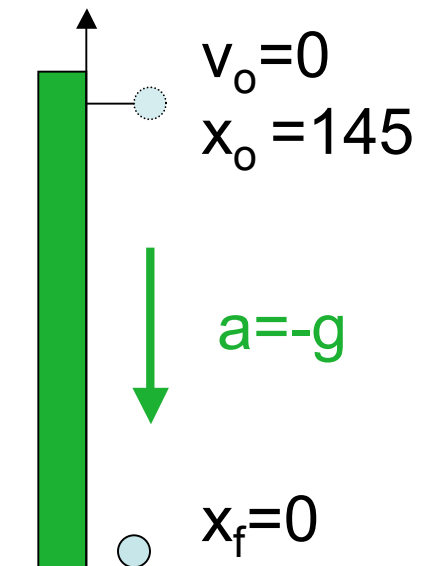
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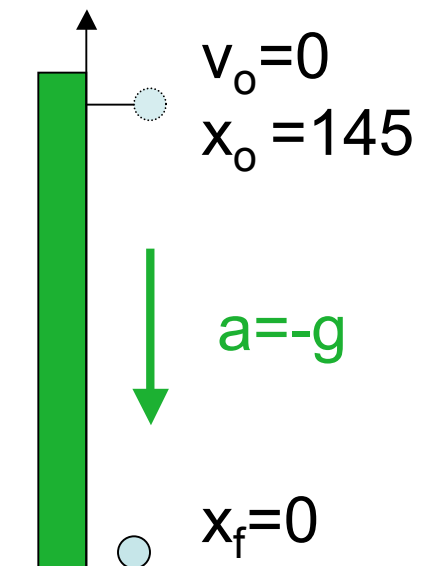
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$$t = \sqrt{\frac{2(x_f - x_0)}{a_x}} = \sqrt{\frac{2(-145 \text{ m})}{-9.80 \text{ m s}^{-2}}} = 5.44 \text{ s}$$



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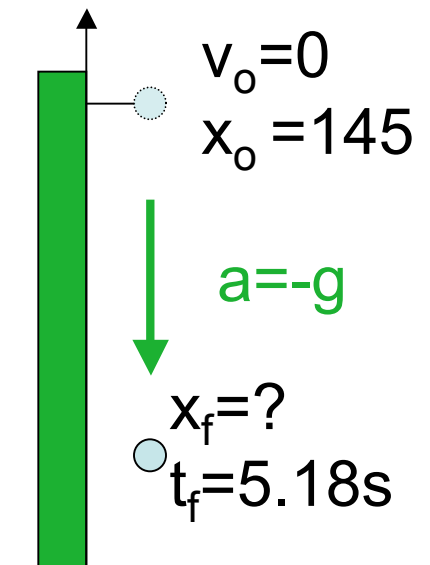
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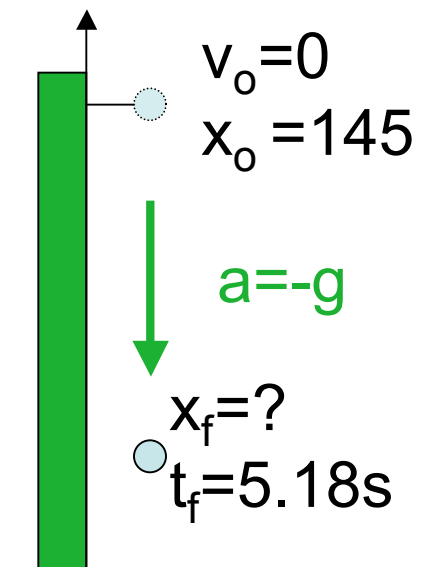
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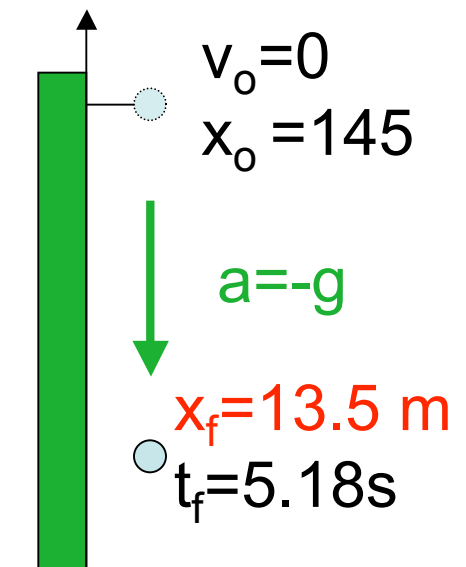
B $x - x_0 = v_0t + \frac{1}{2}at^2$

C $v^2 = v_0^2 + 2a(x - x_0)$

$x_f = 145 \text{ m} + 0 (5.18 \text{ s}) - 0.5 \times 9.8 \text{ m s}^{-2} (5.18 \text{ s})^2$

D $x - x_0 = \frac{v_0 + v_f}{2}t$

E $x - x_0 = vt - \frac{1}{2}at^2$



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What constant acceleration would be required to stop an experiment package in the distance remaining in the shaft after its 5.18-s fall?

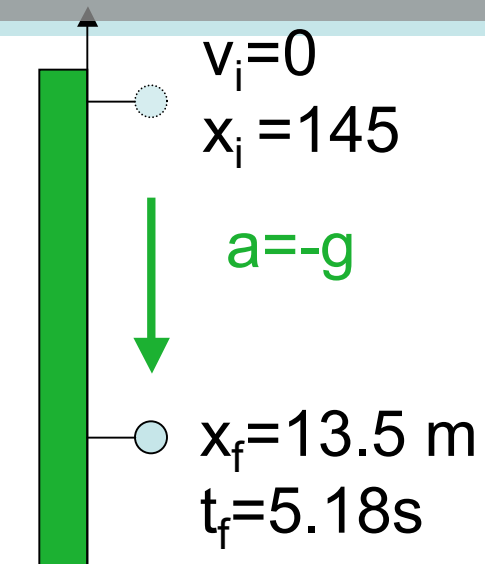
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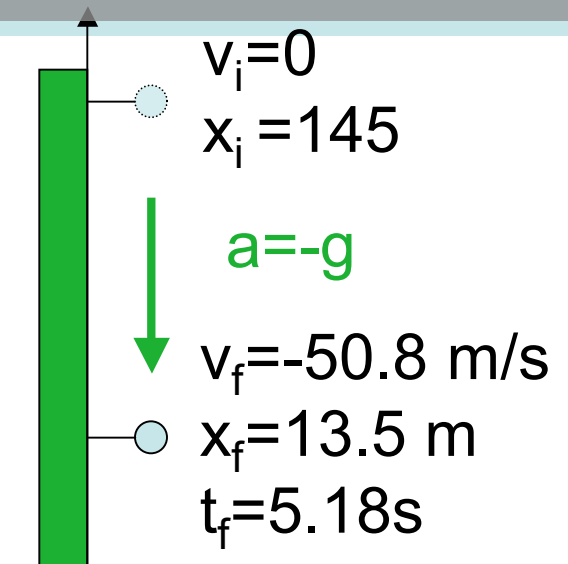
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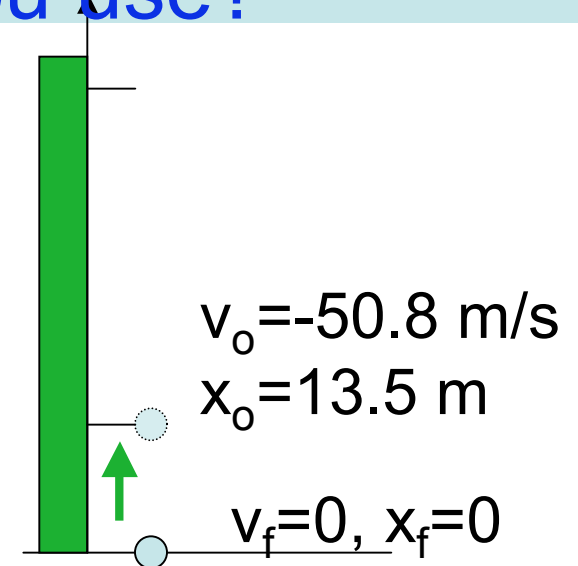
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63. A motorist drives along a straight road at a constant speed of 15.0 m/s . Just as she passes a parked motorcycle police officer, the officer starts to accelerate at 2.00 m/s^2 to overtake her. Assuming the officer maintains this acceleration, (a) determine the time it takes the police officer to reach the motorist. Find (b) the speed and (c) the total displacement of the officer as he overtakes the motorist.

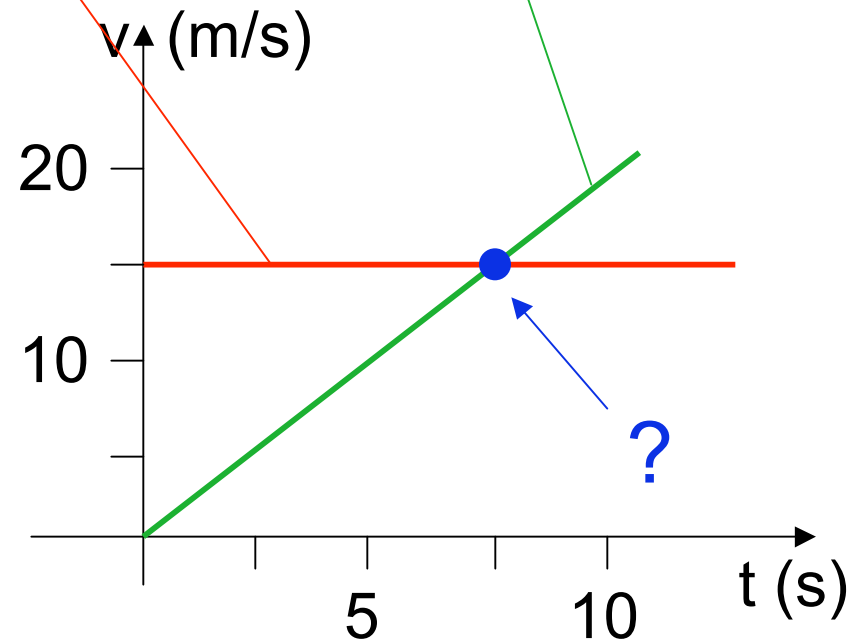
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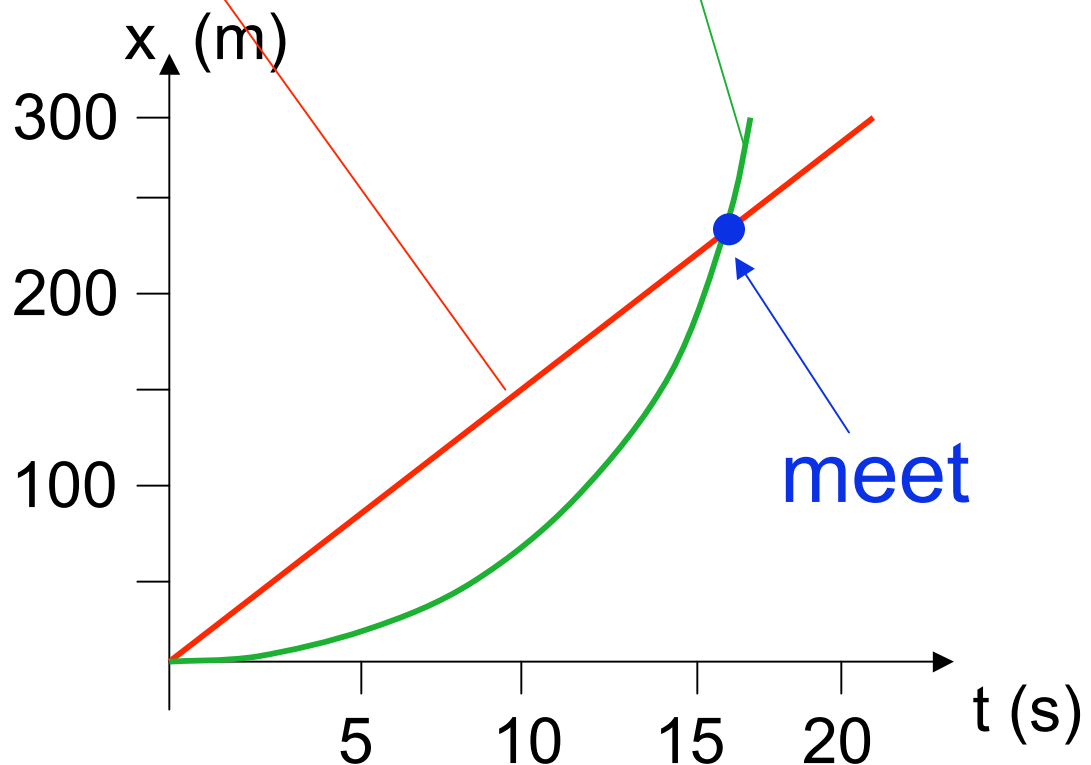
- A. Position vs. t
- B. Velocity vs. t ?
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Which diagram would be helpful for solving this problem?

- A. Position vs. t
- B. Velocity vs. t
- C. Acceleration vs. t
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63. A motorist drives along a straight road at a constant speed of 15.0 m/s. Just as she passes a parked motorcycle police officer, the officer starts to accelerate at 2.00 m/s² to overtake her. Assuming the officer maintains this acceleration, (a) determine the time it takes the police officer to reach the motorist. Find (b) the speed and (c) the total displacement of the officer as he overtakes the motorist.

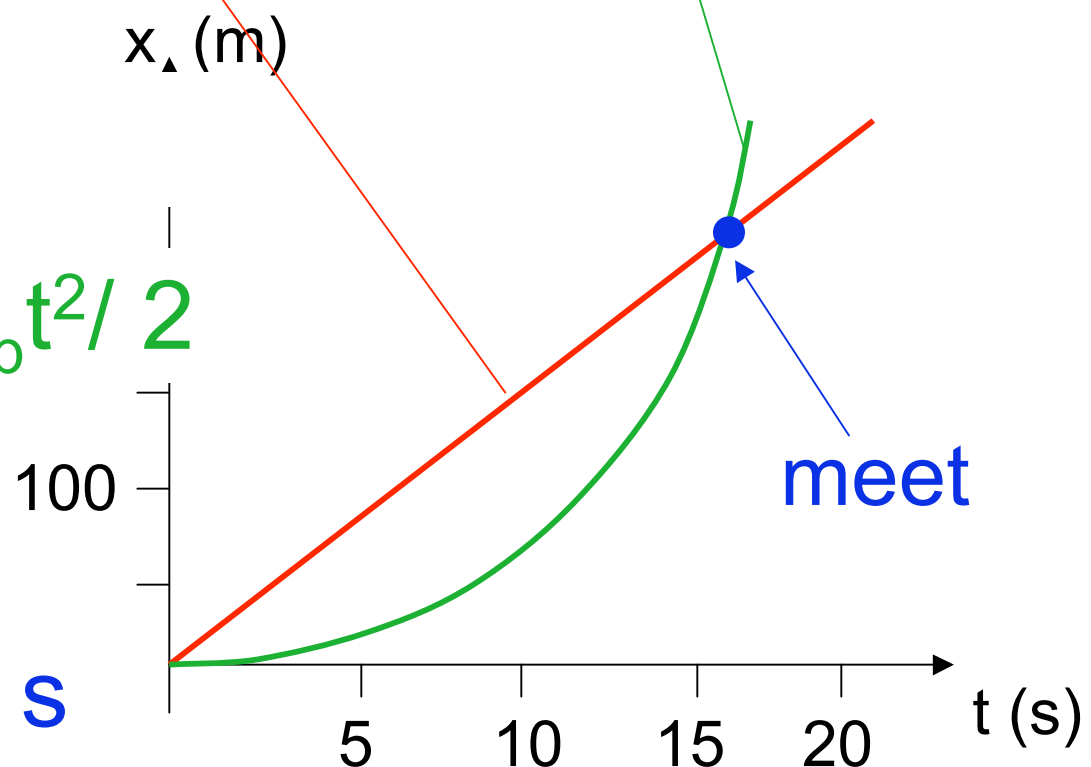
$$x - x_0 = v_0 t + \frac{1}{2} a t^2$$

$$x_c = 0 + v_c t + 0$$

$$x_p = 0 + 0 + a_p t^2 / 2$$

$$v_c t = a_p t^2 / 2$$

$$t = 2 v_c / a_p = 15 \text{ s}$$



Equations for constant a

Equation	Missing Quantity
----------	------------------

$$v = v_0 + at$$

$$x - x_0$$

$$x - x_0 = v_0t + \frac{1}{2}at^2$$

$$v$$

$$v^2 = v_0^2 + 2a(x - x_0)$$

$$t$$

$$x - x_0 = \frac{1}{2}(v_0 + v)t$$

$$a$$

$$x - x_0 = vt - \frac{1}{2}at^2$$

$$v_0$$

- Choose eq. containing the **unkown** and things you know
- Solve for the **unknown**

Equations for constant a

Equation

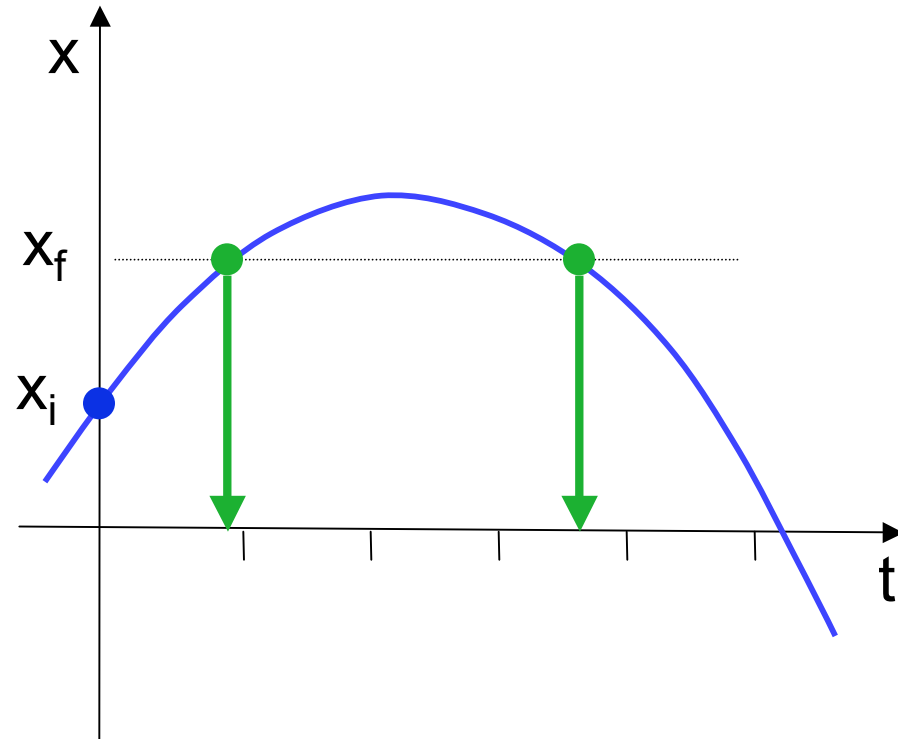
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- Choose eq. containing the **unkown** and things you know
- Solve for the **unknown**

Dana bounces a super-ball off the classroom floor so hard that it hits the ceiling, 3.0 m overhead. The ball leaves the floor going straight upward at 20 m/s. How much time before it hits the ceiling?

$$x_f - x_o = v_o t + \frac{1}{2} a t^2$$

Which is the quadratic eq. you must solve?

A $4.9t^2 + 20t + 3 = 0$

B $-4.9t^2 + 20t - 3 = 0$

C $-4.9t^2 - 20t + 3 = 0$

D $-4.9t^2 + 20t + 3 = 0$

Dana bounces a super-ball off the classroom floor so hard that it hits the ceiling, 3.0 m overhead. The ball leaves the floor going straight upward at 20 m/s. How much time before it hits the ceiling?

$$t = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$\mathbf{B} \quad -4.9t^2 + 20t - 3 = 0$$

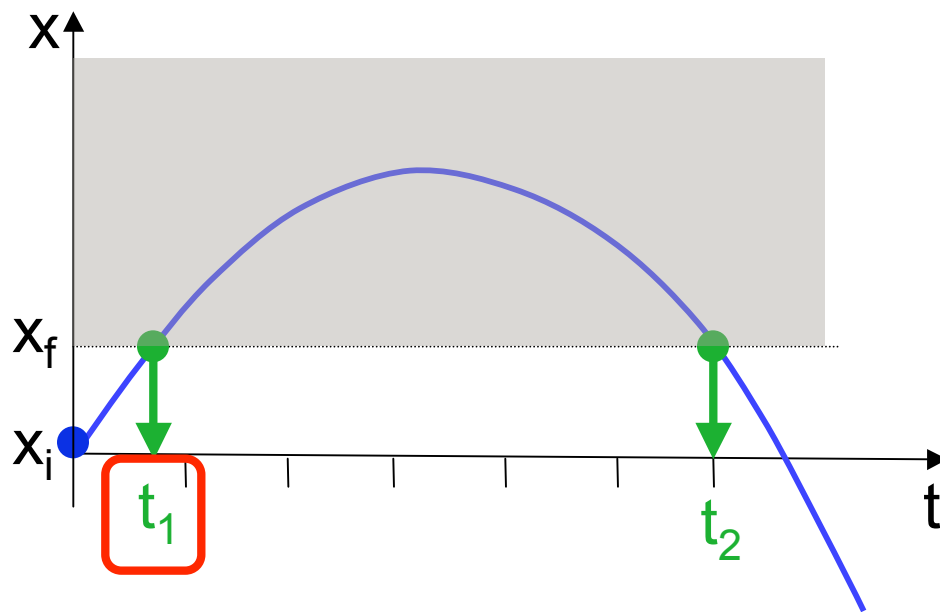
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$$\text{B} \quad -4.9t^2 + 20t - 3 = 0$$

$$t = \frac{-20 \pm \sqrt{(20)^2 - 4(-4.9)(-3)}}{2(-4.9)} = \frac{-20 \pm 18.5}{-9.8}$$

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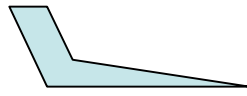
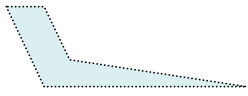
$$t_1 = 0.15 \text{ s}$$

$$t_2 = 3.9 \text{ s}$$

$$t = \frac{-20 \pm \sqrt{(20)^2 - 4(-4.9)(-3)}}{2(-4.9)} = \frac{-20 \pm 18.5}{-9.8}$$

$$v_i = 63 \text{ m/s}$$

$$v_f = 0$$



$$x_i = 0$$

$$x_f = ?$$

$$t_i = 0$$

$$t_f = 2 \text{ s}$$

The area under the curve:

$$\begin{aligned} A &= \frac{1}{2} h w \\ &= \frac{1}{2} (63 \text{ m/s}) (2 \text{ s}) \\ &= 63 \text{ m} \end{aligned}$$

$$\Delta x = \int_{t_o}^{t_f} v(t) dt$$

What property of the v vs. t curve will tell me x_f ?

- A y intercept
- B slope
- C x intercept
- D area
- E color

