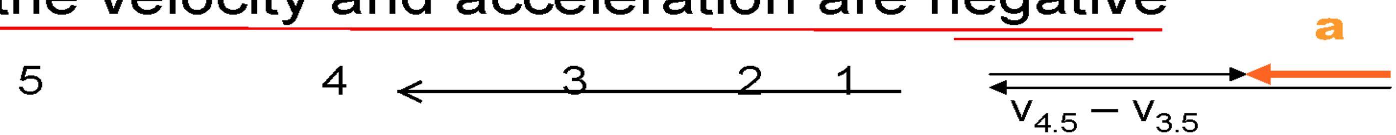
Thinking about Directions

Let's define right to be the positive direction , $\Delta t = 1$ s.

Both the velocity and acceleration are positive

Both the velocity and acceleration are negative



When the velocity and the acceleration are in the same direction the object

1.___________speeds up_______________ .

2._________slows down_________________ .

Thinking about Directions

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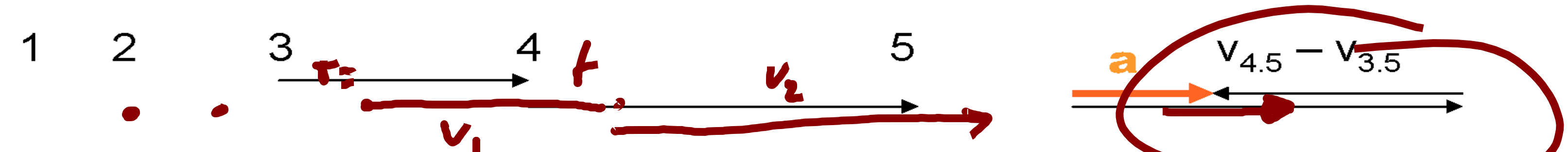
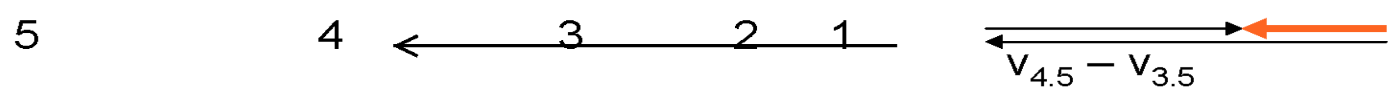


Both the velocity and acceleration are negative



When the velocity and the acceleration are in the same direction the object

1. ___________speeds up______________ .

2. ________slows down________________ .

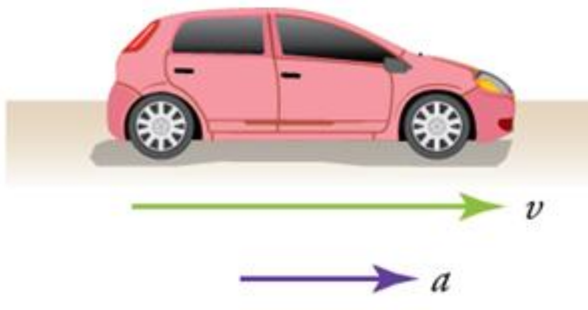
$$a = \frac{\Delta v}{\Delta t} = \frac{v_2 - v_1}{\Delta t} =$$

$$= \frac{\quad}{\Delta t}$$

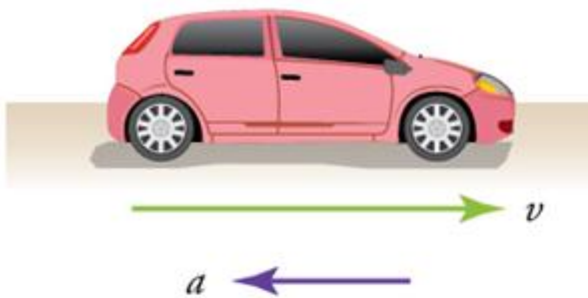
$$= \frac{\quad}{\Delta t} =$$

Which picture shows a speeding up (slowing down) car?

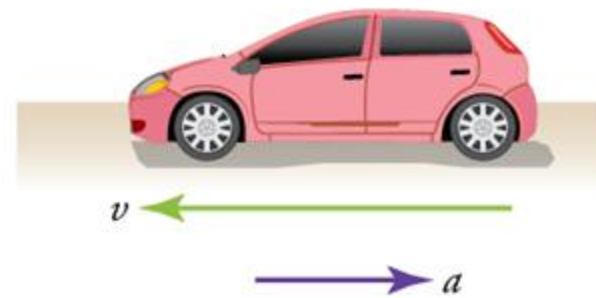
a)



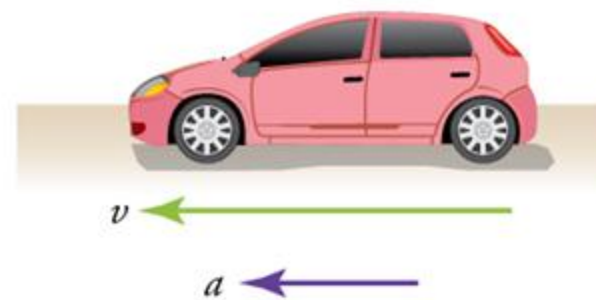
b)



c)



d)

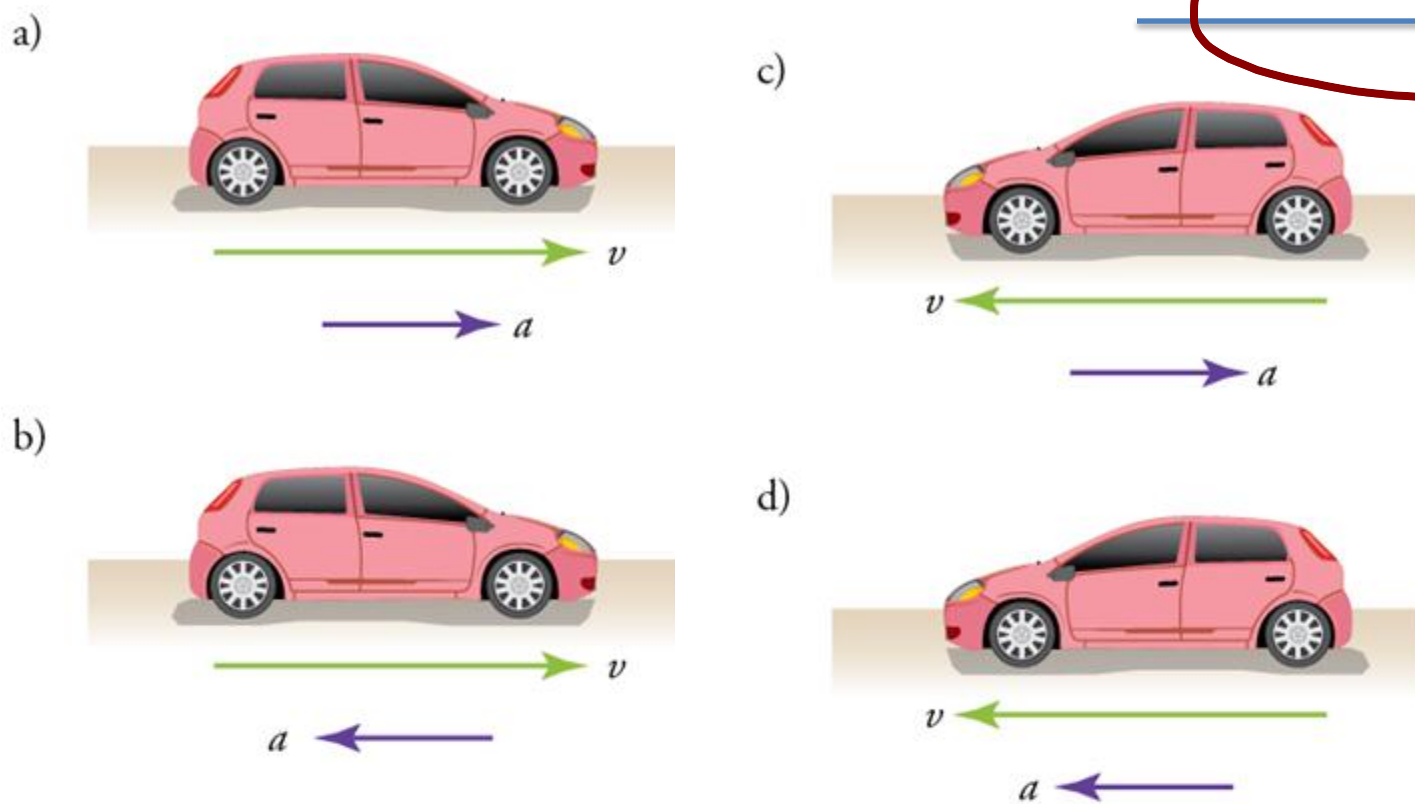


1. **only a**   2. **only b**   3. **only c**   4. **only d**

5. **a, b**   6. **c, d**   7. **a, d**   8. **b, c**   9. **none of them**

0. **all of them**

Which picture shows a speeding up (slowing down) car?



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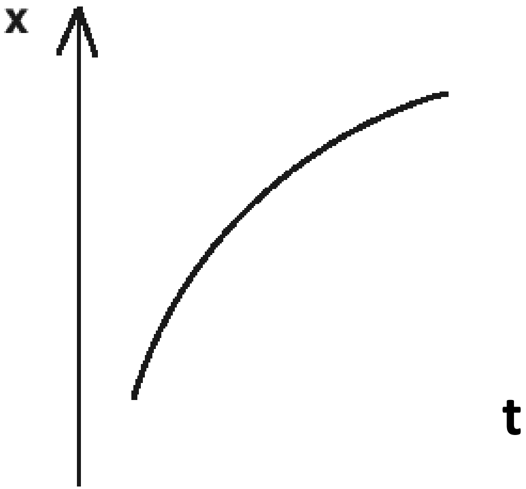
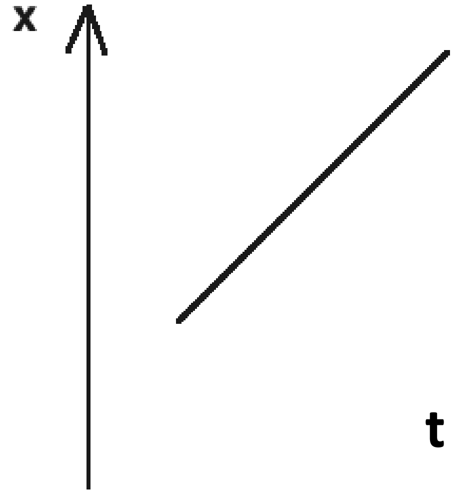
5. **a, b** 6. **c, d** 7. **a, d** 8. **b, c** 9. **none of them**

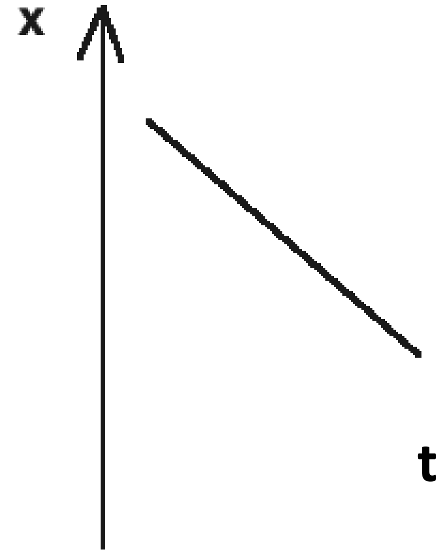
0. **all of them**



A)



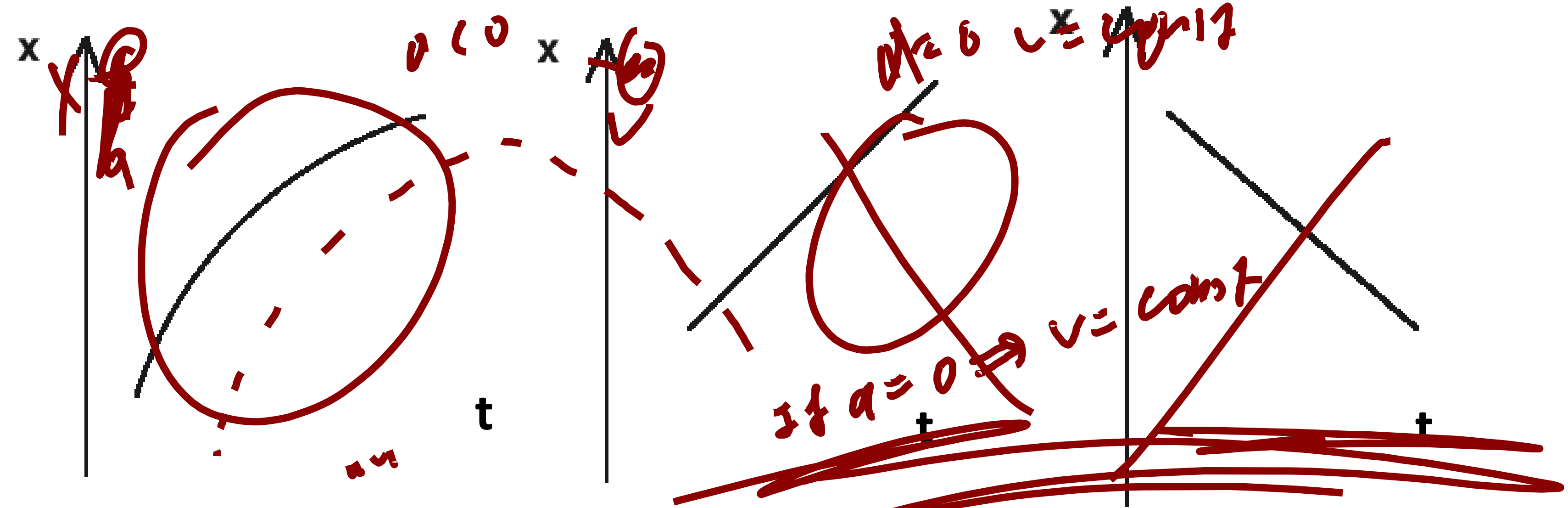
B)



C)

Which if the graphs above CANNOT represent a motion with a *constant (≠ 0 !)* acceleration?

1. **Only A**
2. **Only B**
3. **Only C**
4. **A, B**
5. **A, C**
6. **B, C**
7. **all of them**
8. **none of them**



A) **B)** **C)**

Which of the graphs above CANNOT represent a motion with a *constant (≠ 0 !)* acceleration?

1. **Only A**
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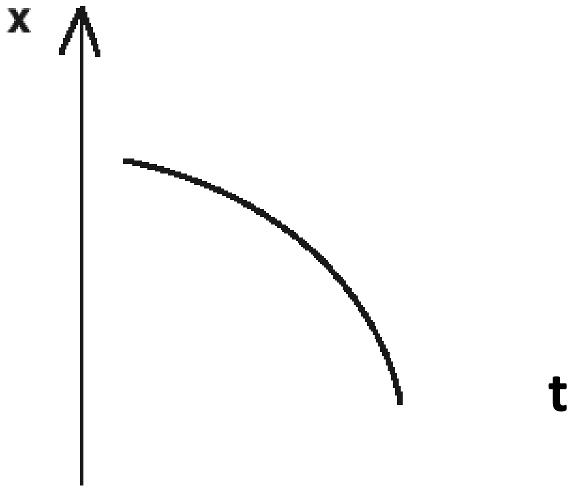
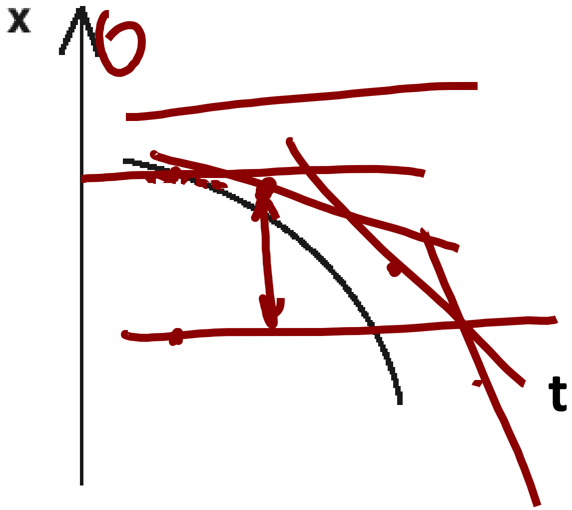


Let's say the graph represents MCA, sketch graphs v(t), and a(t).



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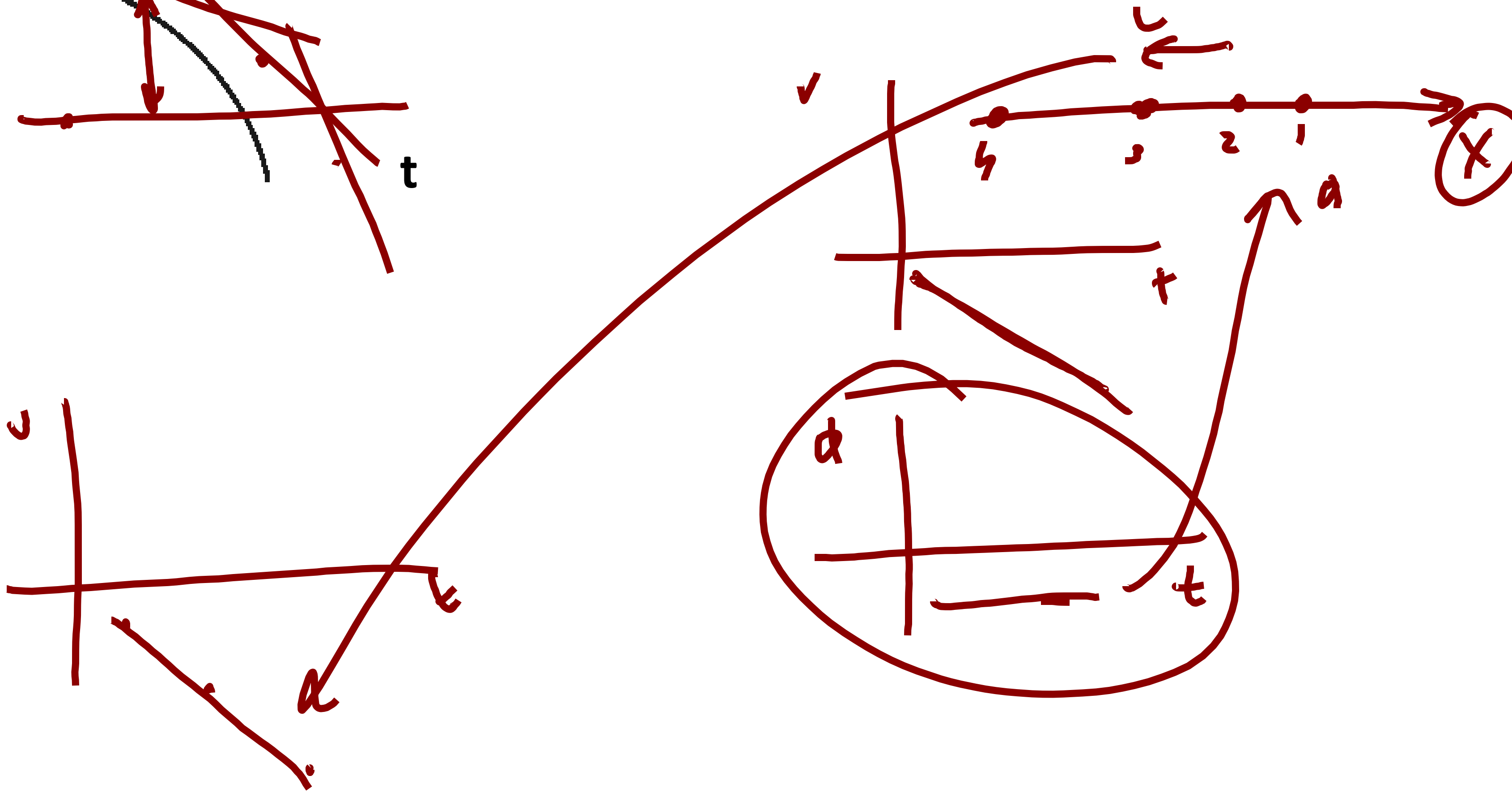
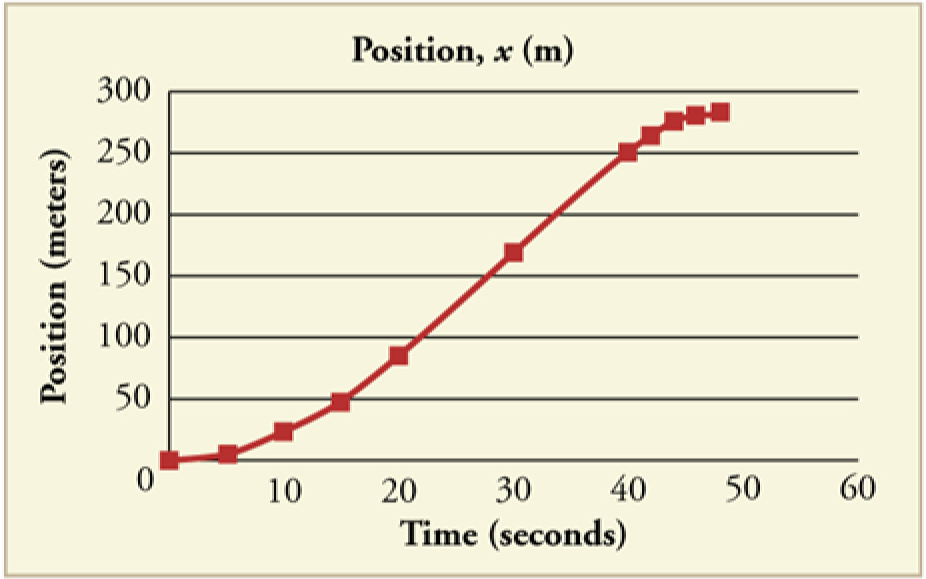
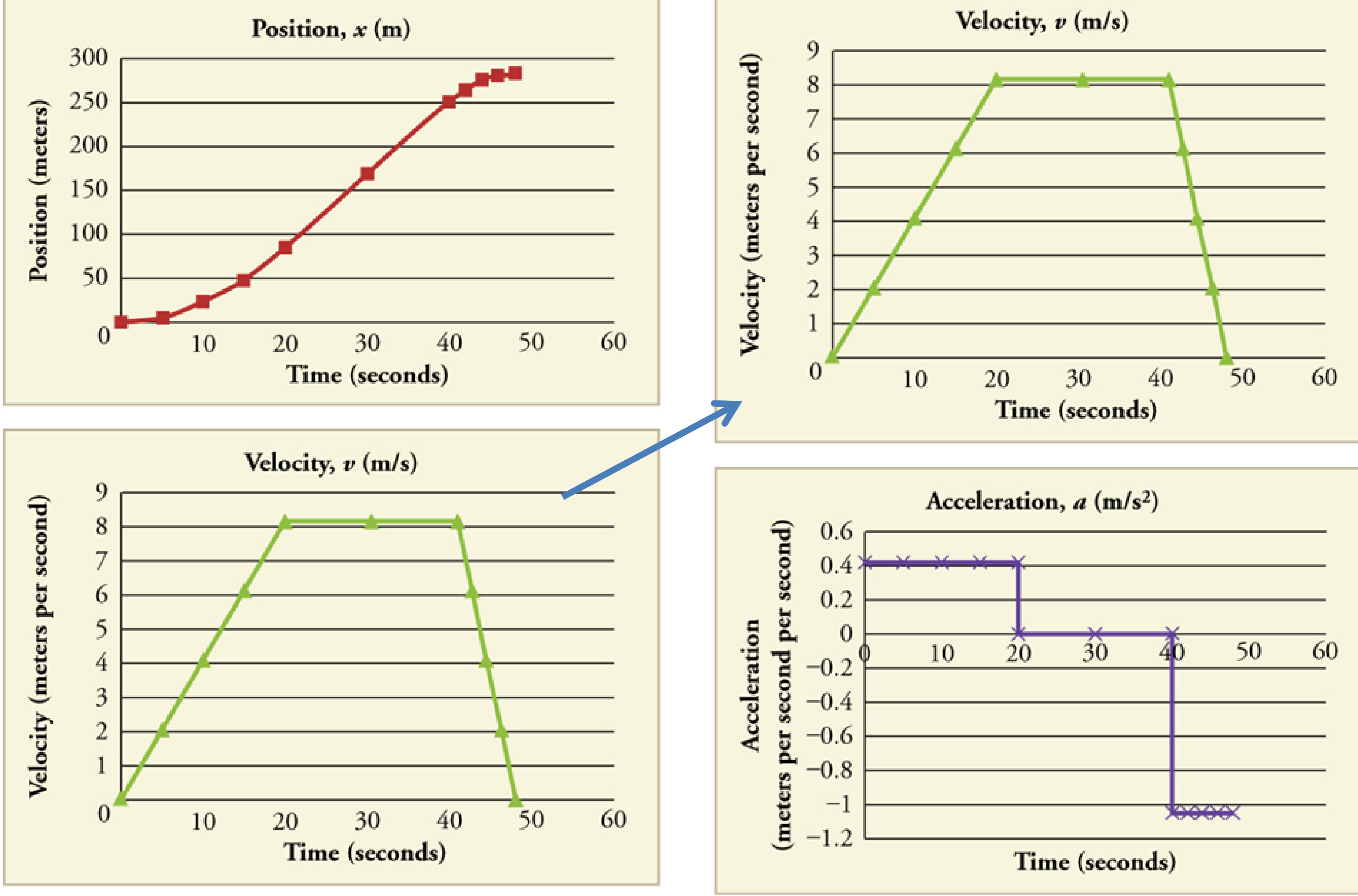
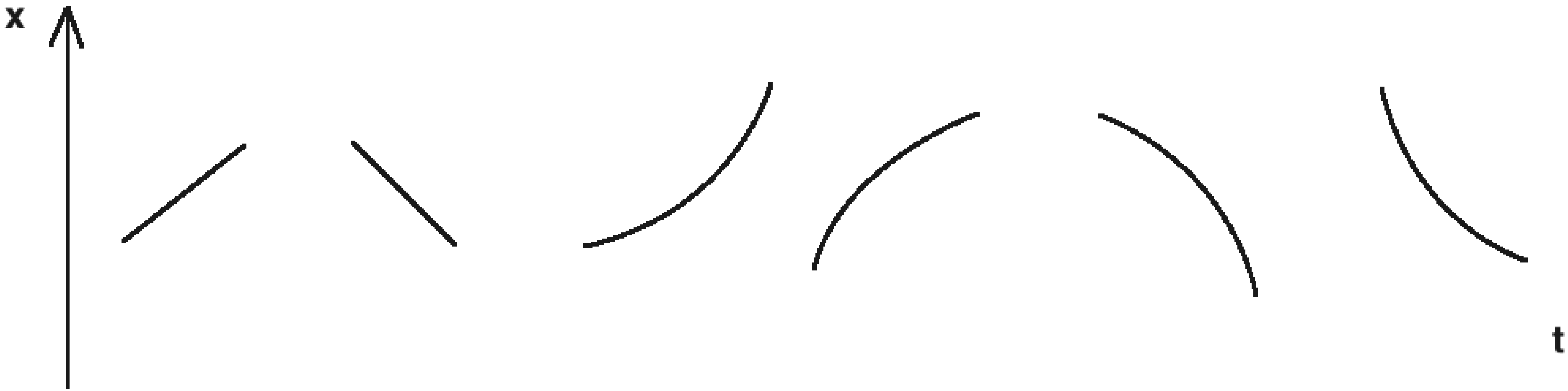




For the given Position vs. Time graph, plot the graph Velocity vs. Time, and Acceleration vs. Time

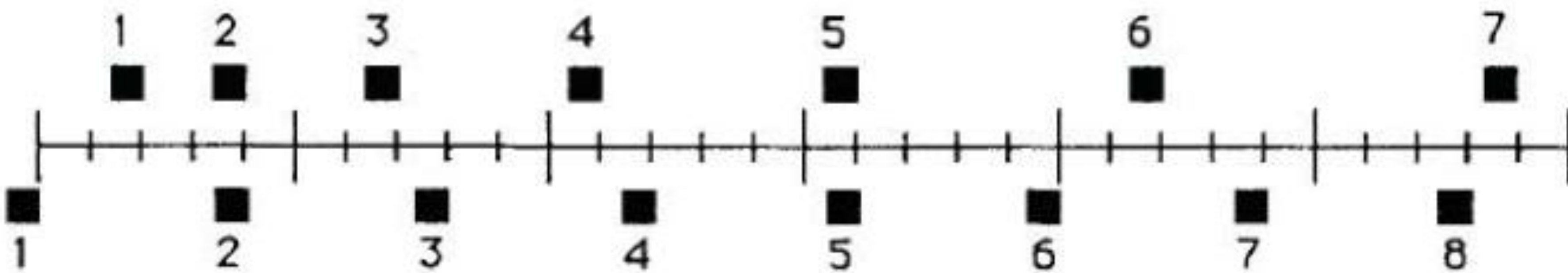

Position, x (m)
Position (meters)
300
250
200
150
100
50
0
10
20
30
40
50
60
Time (seconds)
Velocity, v (m/s)
Velocity (meters per second)
9
8
7
6
5
4
3
2
1
0
10
20
30
40
50
60
Time (seconds)
Velocity, v (m/s)
Velocity (meters per second)
9
8
7
6
5
4
3
2
1
0
10
20
30
40
50
60
Time (seconds)
Acceleration, a (m/s²)
Acceleration (meters per second per second)
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
−0.8
−1
−1.2
0
10
20
30
40
50
60
Time (seconds)

Practice at home



Sketch graphs v(t), a(t); learn to recognize cases with $a = 0$, $a > 0$, $a < 0$.

In the picture, numbered squares represent the positions of two blocks at successive equal time intervals. The blocks are moving toward the right.



Do the blocks ever have the same speed?

(A) No.

(B) Yes, at instant 3.

(C) Yes, at Instant 4.

(D) Yes, at instant 3 and 4.

(E) Yes, at some time during Interval 3 to 4.

In the picture, numbered squares represent the positions of two blocks at successive equal time intervals. The blocks are moving toward the right.

$\frac{4}{1\,s}{}^{m} = V_{Ave\,1}$

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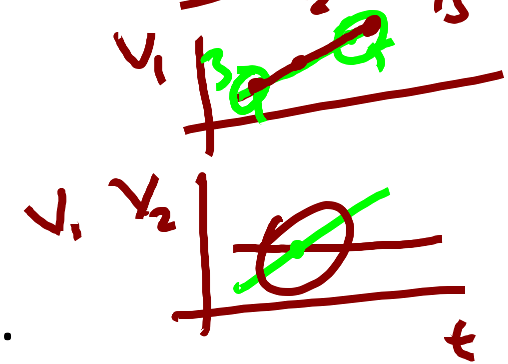
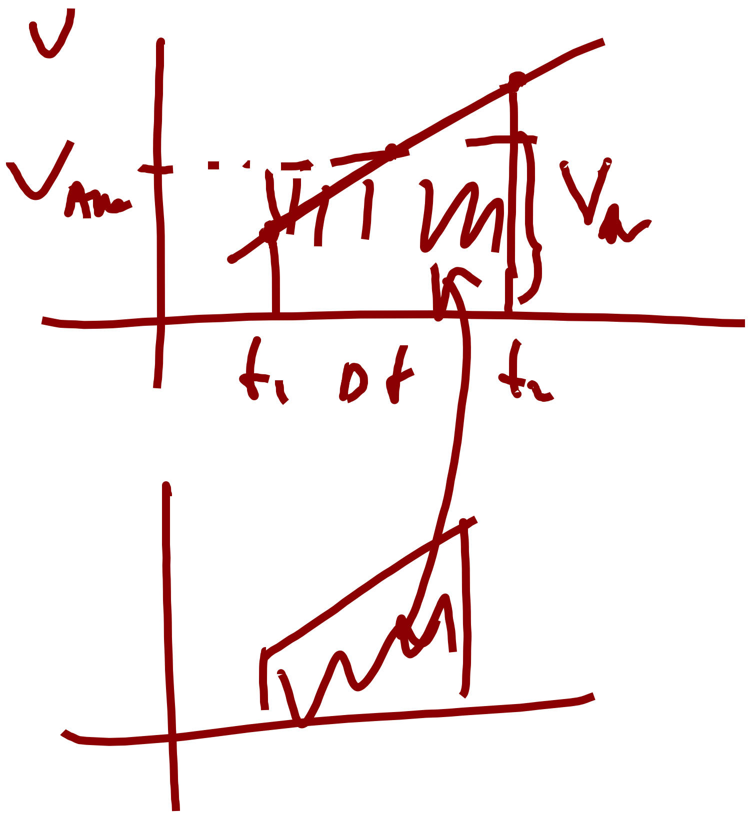
(C) Yes, at Instant 4.

(D) Yes, at instant 3 and 4.

(E) Yes, at some time during Interval 3 to 4.

$V_2 = \frac{4m}{1s}$





$$V_{AV} = \frac{\Delta x}{\Delta t}$$

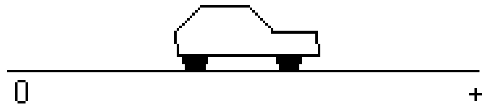
$$\Delta x = \underline{V_{AV}} \cdot \Delta t$$

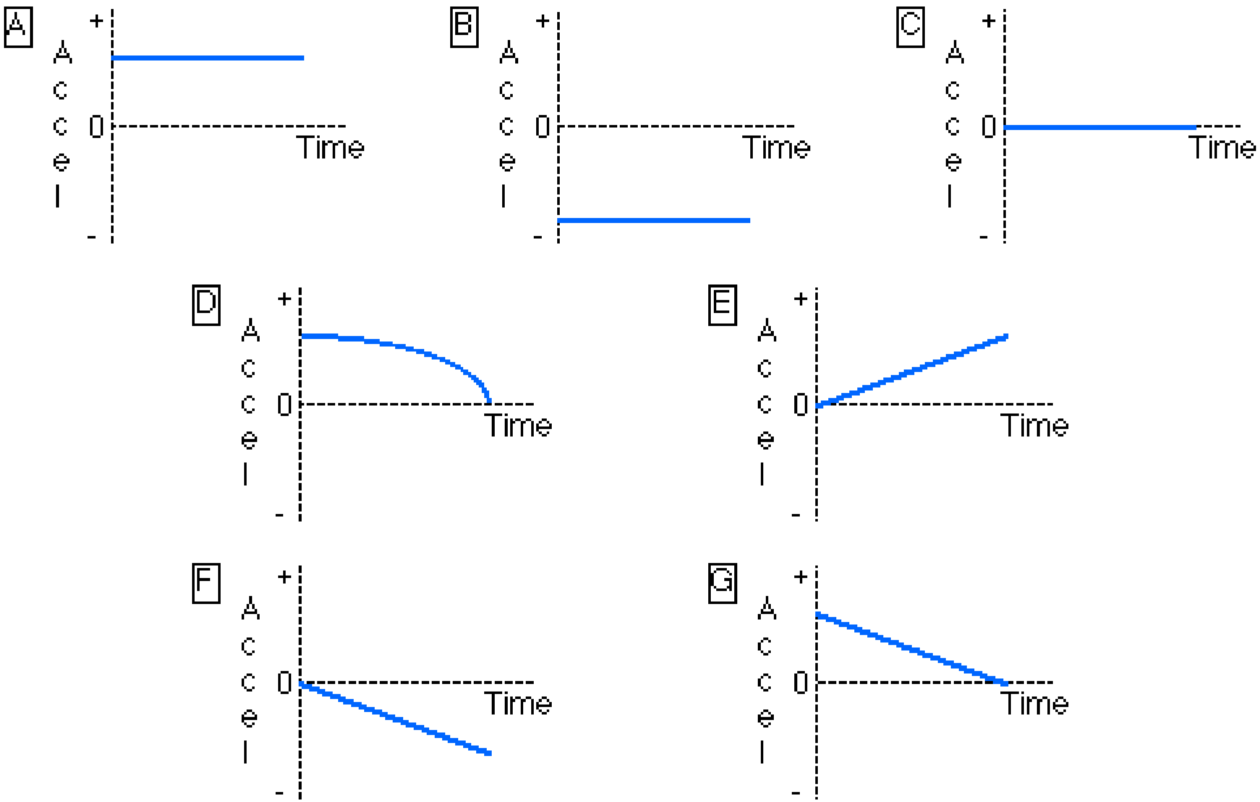
3 4

0 0

$$V_{AV} = 4$$

A toy car which can move to the right or left along a horizontal line (the + distance axis). Different motions of the car are described below.



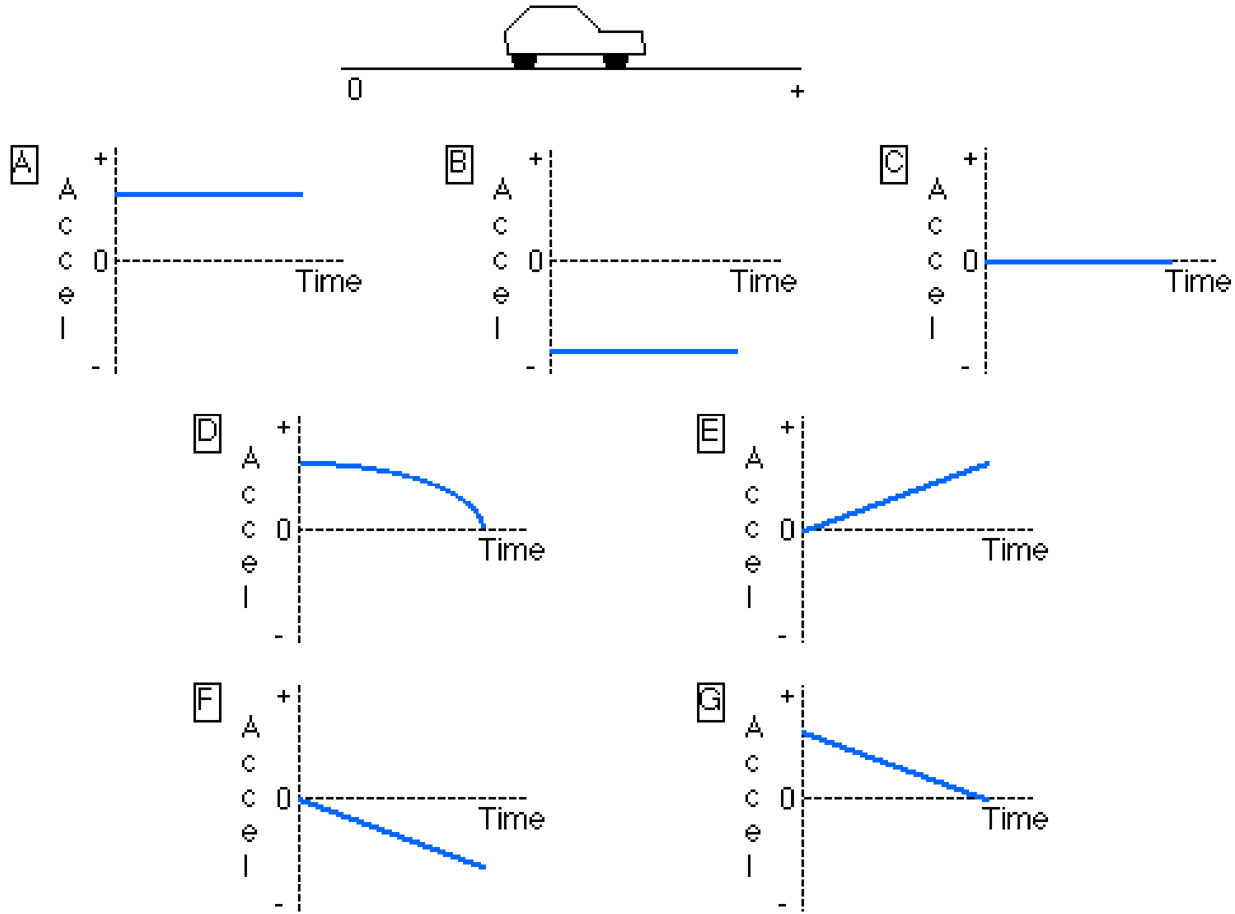


Choose the acceleration-time graph which corresponds to the motion of the car.

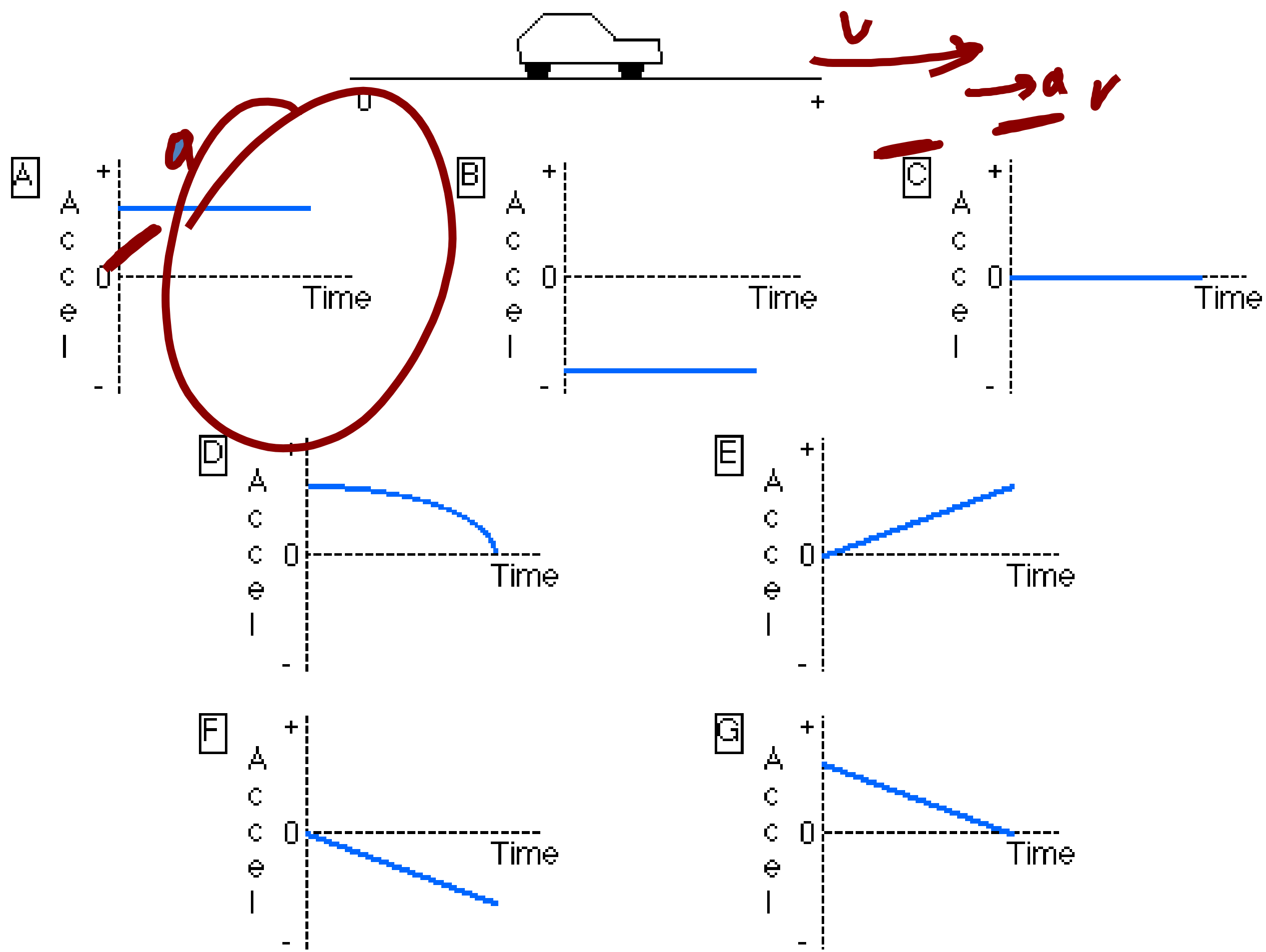
(a) The car moves toward the right (away from the origin), speeding up at a steady rate.

A toy car which can move to the right or left along a horizontal line (the + distance axis). Different motions of the car are described below. (b) it moves to the right, slowing down at a steady rate. (c) it moves to the left, speeding up at a steady rate.

(d) The car moves toward the right at a constant velocity.



A toy car which can move to the right or left along a horizontal line (the + distance axis). Different motions of the car are described below.



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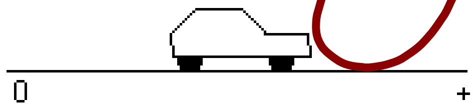
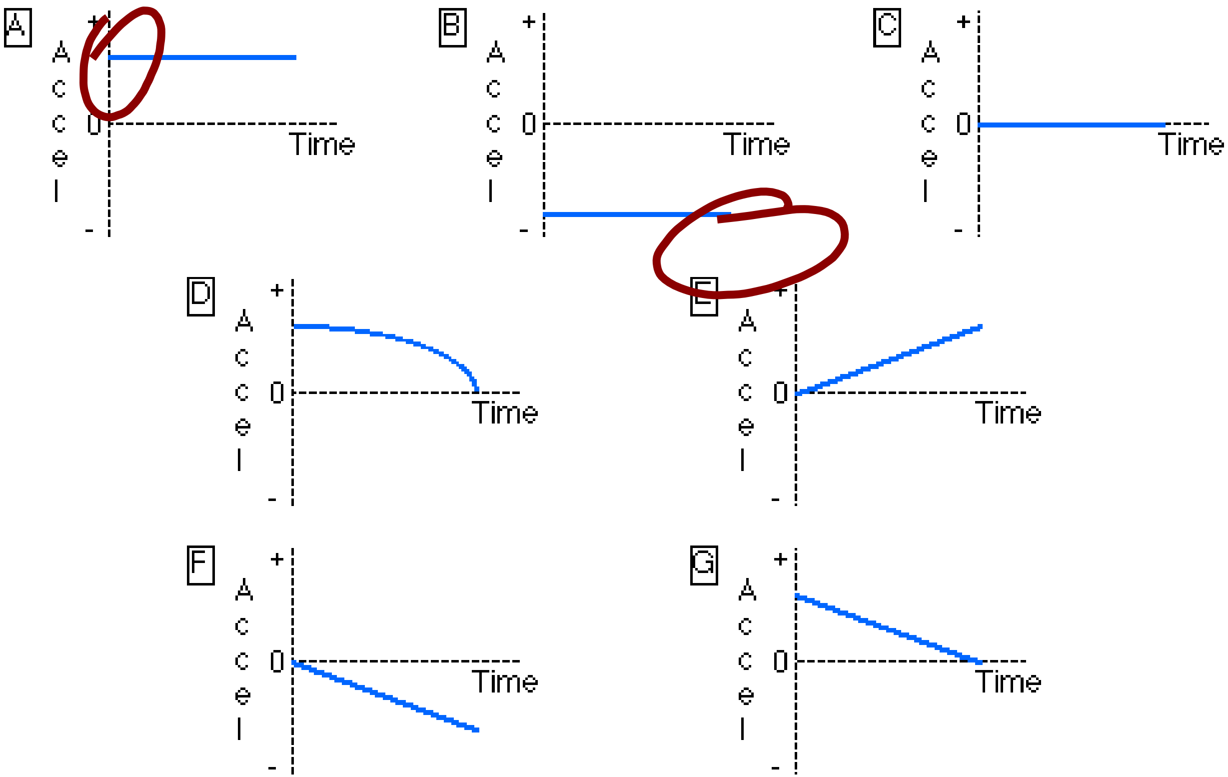


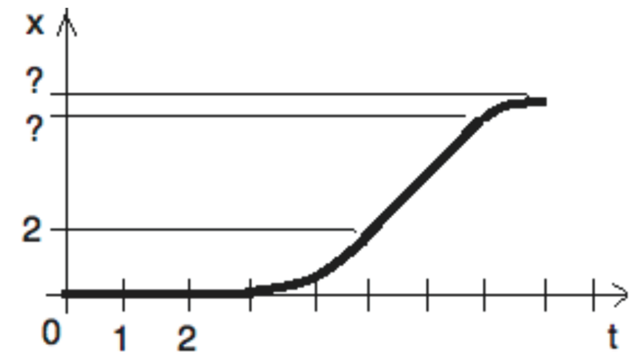
v

a = const



Example

The graph on the right shows the motion graph for a linearly moving object. It is seen that the motion starts from rest and after being in motion for 2 seconds the object reaches location x = 2 m.



1. Qualitatively describe the motion of the object for different time intervals. $0 < t < 3$ $\quad 3 < t < 5$ $\quad 5 < t < 7$ $\quad 7 < t < 8$

2. For each time interval find the displacement, initial, final, and average velocities, initial and final position, and acceleration of the object (you can do your calculations in another order).

$0 < t < 3$

$\Delta x =$ $\quad x_0 =$ $\quad x_f =$ $\quad v_0 =$ $\quad v_f =$

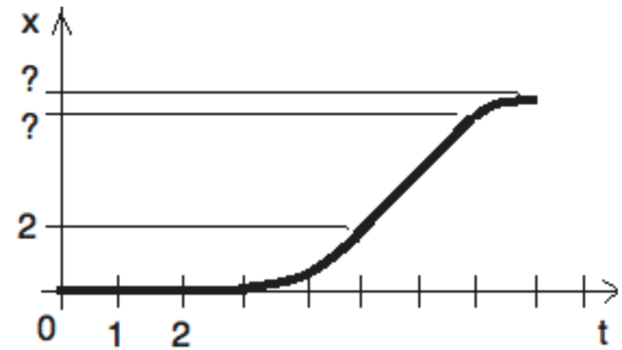
$v_{ave} =$ $\quad a =$

$3 < t < 5$

$\Delta x =$ $x_0 =$ $x_f =$

$v_0 =$ $v_f =$ $v_{ave} =$

$a =$



$5 < t < 7$

$\Delta x =$ $x_0 =$ $x_f =$ $v_0 =$

$v_f =$ $v_{ave} =$ $a =$

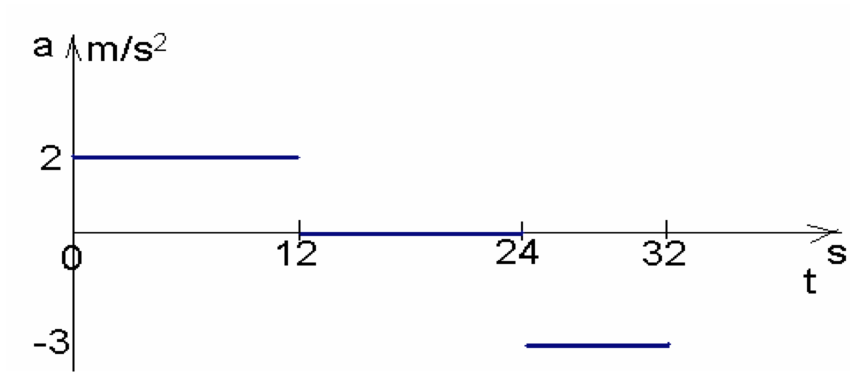
$7 < t < 8$

$\Delta x =$ $x_0 =$ $x_f =$ $v_0 =$

$v_f =$ $v_{ave} =$ $a =$

Problem

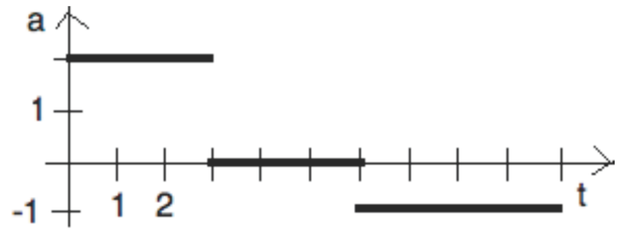
An object starts its motion to the right from rest from the origin. The acceleration of the object is given by the graph.



Plot the graphs for the velocity and displacement of the object.

Practice at home

The graph on the right shows the acceleration of a linearly moving object, which at the initial time is passing the origin with velocity -4 m/s.



1. Qualitatively describe the motion of the object for different time intervals.

$0 < t < 3$ $3 < t < 6$ $6 < t < 10$

2. Plot to scale (not just sketch!) the graph for the velocity of the object as a function of time.

3. Plot to scale (not just sketch!) the graph for the position of the object as a function of time.

Practice at home

1) For a motion with a constant non-zero acceleration the graph for velocity as a function of time should be: ____

2) For a motion with a constant acceleration the equation for velocity as a function of time is $x = mt + b$, where the acceleration is represented by the coefficient ____.

3) For a motion with a constant acceleration the equation for velocity as a function of time is $x = mt + b$, where initial velocity is represented by a coefficient ____

4) For an object moving with a constant acceleration and with the motion equation for position as function of time $x = 3t^2 - 0.5t + 12$ (IS units) write the motion equation for the object's velocity as a function of time.

____________________, where the acceleration $a =$, and the initial velocity $v_0 =$

5) For an object moving with a constant acceleration and with the motion equation for its velocity as function of time $v = -4t + 5$ (IS units) write the motion equation for the object's position as a function of time.

____________________, where the acceleration $a =$, and the initial velocity $v_0 =$

Using the constant acceleration equations

EXAMPLE : A cyclist has an initial velocity of 4.0 m/s directed east . The cyclist then accelerates at 2.0 m/s^2 east for 3.0 seconds.

(a) What is the cyclist's velocity at the end of the 3.0-second acceleration period? _______

(b) How far does the cyclist travel during the 3.0-second acceleration period? _______

Step 1: Get Organized

Draw a picture.

Show the origin. In this case, the cyclist's initial position.

Choose a positive direction. In this case, east .

Organize the data.

Parameter	Value
x_i	0
v_i	+4.0 m/s
a	+2.0 m/s^2
t	3.0 s

Step 2: Solve the problem

Parameter	Value
x_i	0
v_i	+4.0 m/s
a	+2.0 m/s^2
t	3.0 s

(a) $v = v_i + at$

$$v = +4.0\text{ m/s} + (2.0\text{ m/s}^2) \times (3.0\text{ s})$$

$$v = +4.0\text{ m/s} + 6.0\text{ m/s} = +10.0\text{ m/s}$$

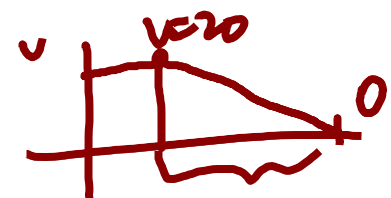
(b) $x - x_i = v_i t + \frac{1}{2}at^2$

$$\Delta x = (+4.0\text{ m/s}) \times (3.0\text{ s}) + \frac{1}{2}(+2.0\text{ m/s}^2) \times (3.0\text{ s})^2$$

$$\Delta x = +12\text{ m} + 9.0\text{ m} = +21\text{ m}$$

Another example of constant acceleration.

EXAMPLE : You are driving your car at 20 m/s when you see a deer in the road 60 m ahead. It takes you 1.0 seconds before you apply the brakes, but then the car slows down and comes to a stop.



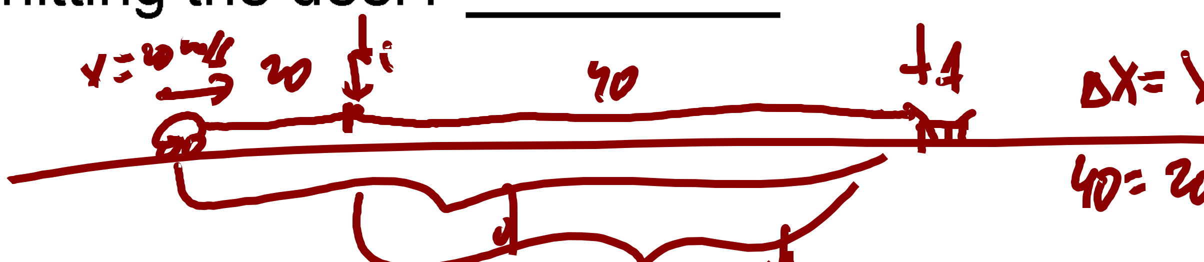
Assuming the car's acceleration is constant what magnitude acceleration (at least) is required to avoid hitting the deer? ___________

$v_f = v_i + a$

$0 = 20 + a$

$\Delta x = v_i \cdot t + \frac{a t^2}{2}$

$40 = 20 \cdot t + \frac{a}{2} t^2$



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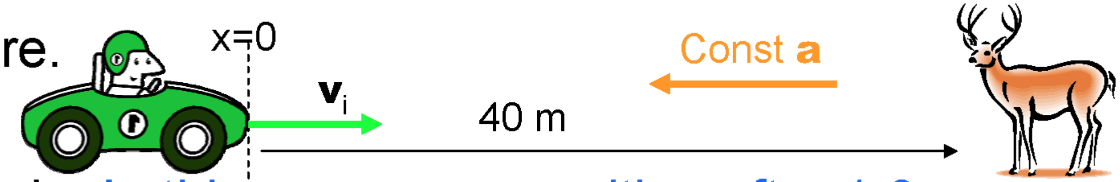
Step 1: Get Organized

Draw a picture.



Show the origin. In this case, your position after 1.0 s.

Choose a positive direction. Your direction of motion.

You travel 20 m in 1.0 s, so now the deer is only 40 m away.

Organize the data.

Parameter	Value
x_i	0
x_f	+40 m
v_i	+20 m/s
v_f	0

Step 2: Solve the problem

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

$$a = \frac{v^2 - v_i^2}{2(x - x_i)}$$

$$a = \frac{0 - (+20\ \text{m/s})^2}{2 \times [(+40\ \text{m}) - 0]}$$

$$a = \frac{-400\ \text{m}^2/\text{s}^2}{+80\ \text{m}} = -5.0\ \text{m/s}^2$$

Parameter	Value
x_i	0
x	+40 m
v_i	+20 m/s
v	0

The magnitude of the acceleration must be at least 5.0 m/s^2.

A Question about acceleration

You throw a ball straight up into the air. While the ball is in free fall (just after it leaves your hand until just before you catch it), which of the following describes the ball's acceleration? (Neglect air resistance).

The ball's acceleration is:

1. Directed down on the way up, zero at the top, and directed up on the way down.
2. Decreasing in magnitude on the way up, and increasing in magnitude on the way down.
3. Constant the entire time.
4. Constant the entire time except at the very top when it is momentarily equal to zero.

A Question about acceleration

You toss a coin straight up into the air. Describes the coin's acceleration (neglect air resistance) when it is: (a) is moving upward after it is released. (b) is at its highest point. (c) is moving downward.

- A - The acceleration is in the negative direction and constant.
- B - The acceleration is in the negative direction and increasing.
- C - The acceleration is in the negative direction and decreasing.
- D - The acceleration is zero.
- E - The acceleration is in the positive direction and constant.
- F - The acceleration is in the positive direction and increasing.
- G - The acceleration is in the positive direction and decreasing.
- J - None of the above.

Two balls of the same size are simultaneously dropped from the roof of a two story building. One weighs twice as much as the other. The time it takes to the balls to reach the ground is:

(A) about half as long for the heavier ball.

(B) about half as long for the lighter ball.

(C) about the same time tor both balls.

(D) considerably less for the heavier ball, but not necessarily half as long.

(E) considerably less for the lighter ball, but not necessarily half as long.

Free fall

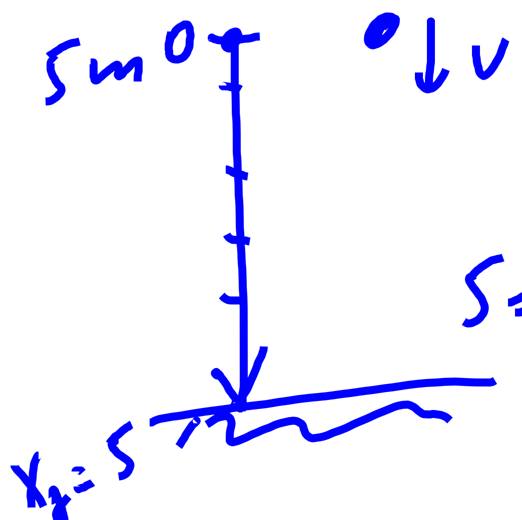
Objects moving under the influence of gravity alone are said to be in free fall. [You can fall up!]

The acceleration of such an object comes from the gravitational force exerted on the object by the Earth. The magnitude of the acceleration is determined by the mass of the Earth, the radius of the Earth, and a number called the universal gravitational constant.

At the Earth's surface, $\vec{g}$, the acceleration due to gravity, equals 9.8 m/s^2 and is directed down.

Question

You release a ball from a rest from a 5 m high barn. How much time will it take for the ball to reach the ground? Find the lending speed of the ball. Assume g = 10 m/s^2.



$V_f = V_0 + a \cdot t$

$S = X_f - X_i$

$= \Delta X = V_0 \cdot t + \frac{a t^2}{2}$

$S = \frac{10 \cdot t^2}{2}$

$t = 1\,s$

$\cancel{t = -1}$

You release a ball from a rest from a 5 m high barn. How much time will it take for the ball to reach the ground? Assume $g = 10\ m/s^2$.

1. **0 s** 2. **-1 s** 3. **1 s** 4. **-2 s** 5. **2 s**

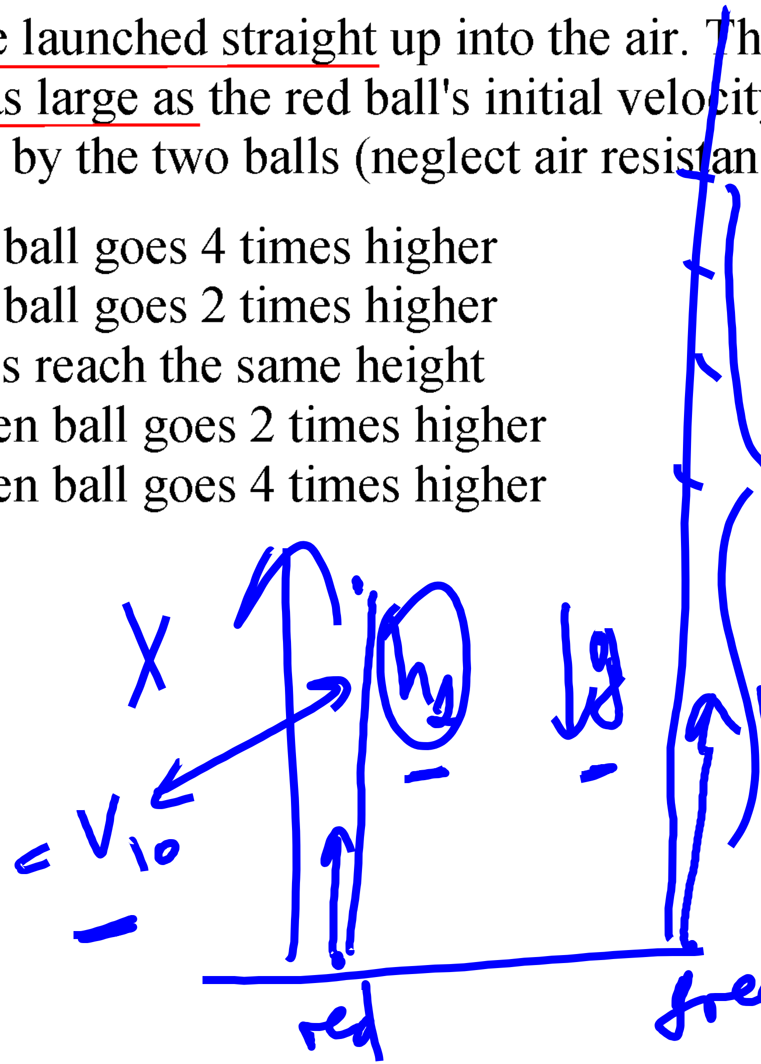
6. **Between 0 and 1 s** 7. **Between 1 and 2 s**

8. **Between 2 and 3 s** 8. **More than 3 s**

1. Two balls are launched straight up into the air. The green ball has an initial velocity twice as large as the red ball's initial velocity. Compare the maximum heights reached by the two balls (neglect air resistance).

A. The red ball goes 4 times higher
B. The red ball goes 2 times higher
C. The balls reach the same height
D. The green ball goes 2 times higher
E. The green ball goes 4 times higher

h_2 vs h_1



$V_{20} = 2 \cdot V_{10}$

$\cancel{v_f = v_i + a_i t}$

$\cancel{h_i = v_i \cdot t + \frac{a t^2}{2}}$

green $\begin{cases} v_f = 0 = v_i - g t \\ h = v_i \cdot t - \frac{g t^2}{2} \end{cases}$

$h \sim V_0^2$

(See the next slide)

Maximum Height

The maximum height, y_{max}, is determined solely by the initial velocity in the y direction and the acceleration due to gravity.

It can be found from the equation:

$$v_y^{\,2} = v_{oy}^{\,2} - 2\,g\,(y_{max} - y_o)$$

We use that:

1) $v_{oy} = v_o$ (we shoot it straight up)

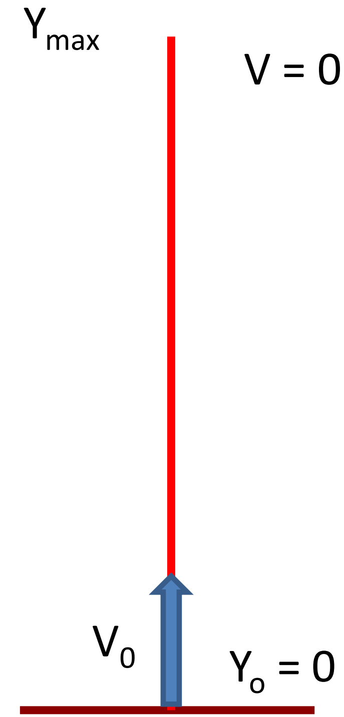
2) when the projectile is at the maximum height, $v_y = 0$.

3) $y_o = 0$ (the natural choie)

Solving the equation for y_{max} gives:

$$\boxed{y_{max} = \frac{v_o^{\,2}}{2\,g}}$$

where $g = 9.8\ m/s^2$



Y_{max} is measured from the initial location, NOT from the ground!

Double speed => quadruple MAX hight.