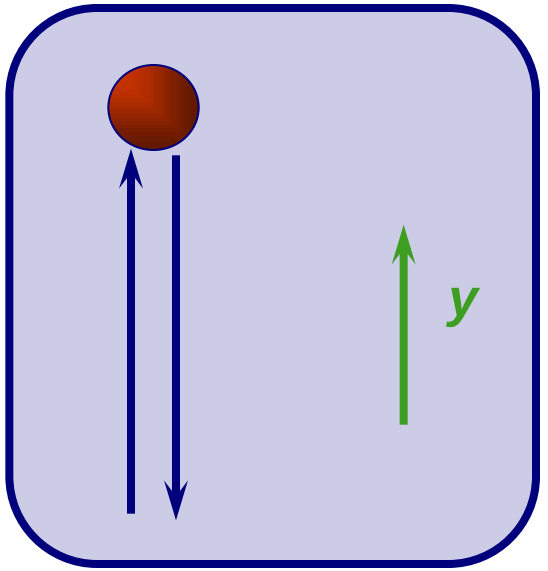
When throwing a ball straight up, which of the following is true about its velocity *v* and its acceleration *a* at the highest point in its path?

1) both $v = 0$ and $a = 0$
2) $v \neq 0$, but $a = 0$
3) $v = 0$, but $a \neq 0$
4) both $v \neq 0$ and $a \neq 0$
5) not really sure

At the top, clearly $v = 0$ because the ball is momentarily stopped. But the velocity of the ball is changing, so its acceleration is definitely not zero! Otherwise it would remain at rest!!



Follow-up: …and the value of *a* is…?

You throw a ball straight up into the air. After it leaves your hand, at what point in its flight does it have the maximum value of acceleration?

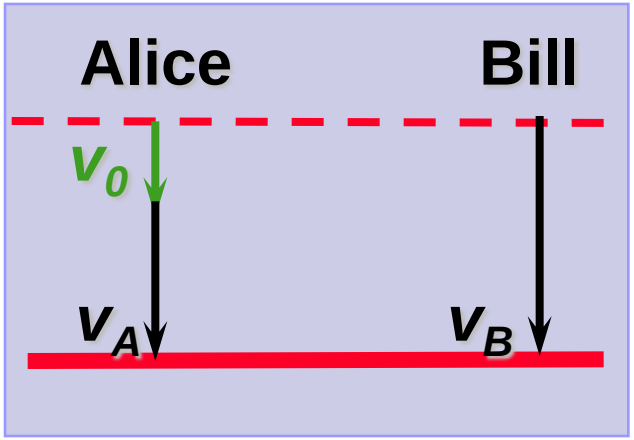
1) its acceleration is constant everywhere
2) at the top of its trajectory
3) halfway to the top of its trajectory
4) just after it leaves your hand
5) just before it returns to your hand on the way down

The ball is in free fall once it is released. Therefore, it is entirely under the influence of gravity, and the only acceleration it experiences is g, which is constant at all points.

Alice and Bill are at the top of a building. Alice throws her ball downward. Bill simply drops his ball. Which ball has the greater acceleration just after release?

1) Alice's ball
2) it depends on how hard the ball was thrown
3) neither -- they both have the same acceleration
4) Bill's ball

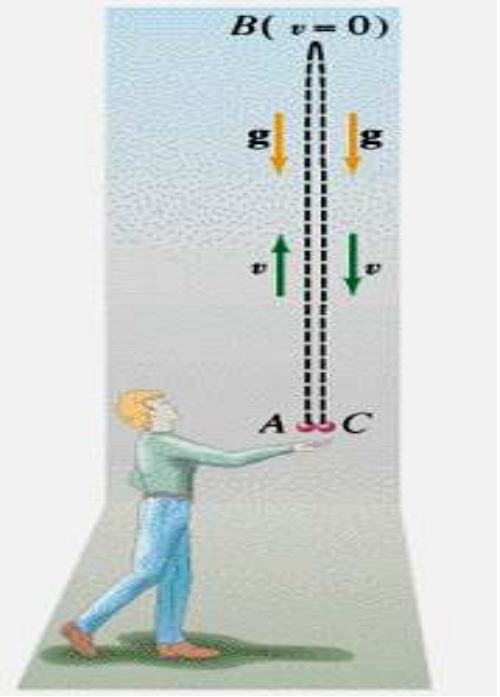
Both balls are in free fall once they are released, therefore they both feel the acceleration due to gravity (*g*). This acceleration is independent of the initial velocity of the ball.



You throw a ball upward with an initial speed of 10 m/s. Assuming that there is no air resistance, what is its speed when it returns to you?

1) more than 10 m/s
2) 10 m/s
3) less than 10 m/s
4) zero
5) need more information

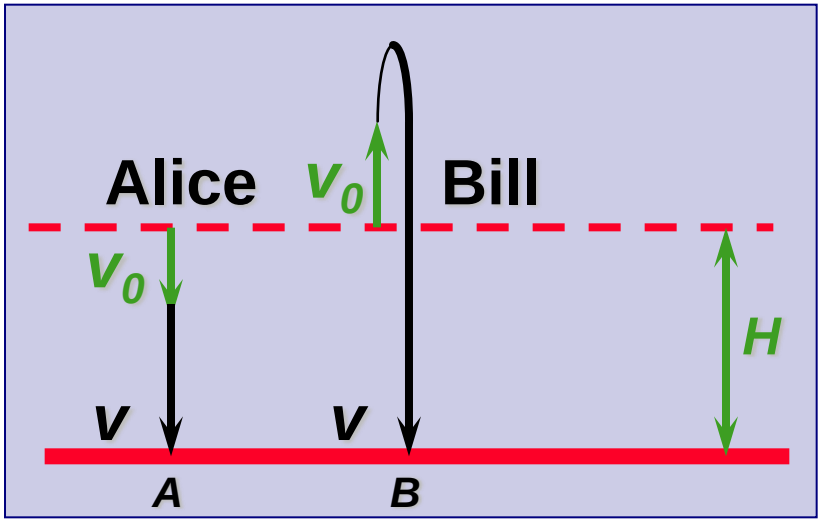
The ball is slowing down on the way up due to gravity. Eventually it stops. Then it accelerates downward due to gravity (again). Since $a = g$ on the way up and on the way down, the ball reaches the same speed when it gets back to you as it had when it left.



Alice and Bill are at the top of a cliff of height H. Both throw a ball with initial speed v_0, Alice straight down and Bill straight up. The speeds of the balls when they hit the ground are v_A and v_B. If there is no air resistance, which is true?

1) $v_A < v_B$
2) $v_A = v_B$
3) $v_A > v_B$
4) impossible to tell

Bill's ball goes up and comes back down to Bill's level. At that point, it is moving downward with v_0, the same as Alice's ball. Thus, it will hit the ground with the same speed as Alice's ball.



Follow-up: What happens if there is air resistance?

A ball is thrown straight upward with some initial speed. When it reaches the top of its flight (at a height *h*), a second ball is thrown straight upward with the same initial speed. Where will the balls cross paths?

1) at height h
2) above height h/2
3) at height h/2
4) below height h/2 but above 0
5) at height 0

The first ball starts at the top with no initial speed. The second ball starts at the bottom with a large initial speed. Since the balls travel the same time until they meet, the second ball will cover more distance in that time, which will carry it over the halfway point before the first ball can reach it.

Follow-up: How could you calculate where they meet?

You drop a rock off a bridge. When the rock has fallen 4 m, you drop a second rock. As the two rocks continue to fall, what happens to their separation?

1) the separation increases as they fall
2) the separation stays constant at 4 m
3) the separation decreases as they fall
4) it is impossible to answer without more information

At any given time, the first rock always has a greater velocity than the second rock, therefore it will always be increasing its lead as it falls. Thus, the separation will increase.

You drop a rock off a bridge. When the rock has fallen 4 m, you drop a second rock. As the two rocks continue to fall, what happens to their velocities?

1) both increase at the same rate
2) the velocity of the first rock increases faster than the velocity of the second
3) the velocity of the second rock increases faster than the velocity of the first
4) both velocities stay constant

Both rocks are in free fall, thus under the influence of gravity only. That means they both experience the constant acceleration of gravity. Since acceleration is defined as the change of velocity, both of their velocities increase at the same rate.