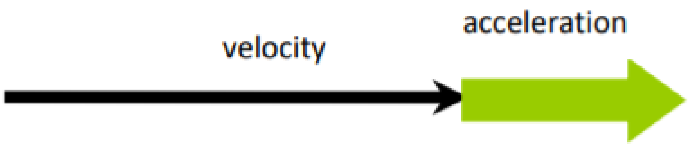
ACCELERATION
OCTOBER 17, 2021

Theory recap

We started discussing acceleration. In everyday life we use the word acceleration to describe increase of the speed of a moving object. Acceleration in physics has a different meaning. It is change in *velocity* per unit time. Any time the speed and/or the direction of motion of an object changes we deal with accelerated motion. There are many examples of accelerated motion: a bike starting moving from rest, a car braking, any object falling. We know that any object (if we could neglect the air drag) falls down with acceleration of 10m/s^2 (9.8 m/s^2, to be exact).

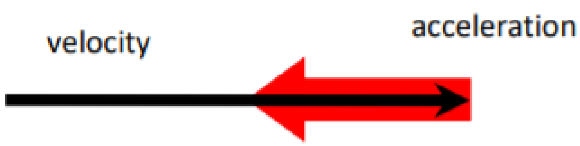
Acceleration is a vector – it has both magnitude and direction. Because of this for the case of rectilinear motion (just to remind – this is the motion along a straight line) there are two major cases:

1. Acceleration is directed along the velocity.



In this case velocity and acceleration have the same sign and speed of the object is *increasing* with time. The acceleration magnitude gives us the rate of the speed increase. For example acceleration of 5 meters per second per second (this is not a typo!) means that the speed increases for 5m/s every second. It is usually denoted as 5m/s^2 (five meter per second squared).

2. Acceleration is directed oppositely to the velocity.



In this case velocity and acceleration have the opposite signs and speed of the object is *decreasing* with time. The acceleration magnitude gives us the rate of the speed decrease. For example, acceleration of -5 meters per second per second means that the speed decreases for 5m/s every second.

For some complicated types of motion (oscillations of a pendulum, for example) acceleration changes with time. We will study only the motion at a constant acceleration ("constant" means "does not change") . If we know acceleration and initial velocity we can easily find the velocity at any later moment:

$$\vec{v} = \vec{v_0} + \vec{a} \cdot t \tag{1}$$

Velocity after the time t = Initial velocity plus **Acceleration** multiplied by the **time**

For example, if you just let a pebble go down, the initial velocity is zero. But you can throw the pebble down. In this case the pebble starts accelerating from nonzero velocity.

Just to remind, arrows on top of some characters in formula (1) mean that the corresponding physical parameters are vectors. When you are solving problems, after you chose the "positive" direction you will be able to put correct signs before v, v_0 and a. After the signs are chosen you can consider these parameters as regular numbers and you do not need to use the arrows anymore.

Homework

When solving these problems you can round the acceleration due to gravity to 10 m/s^2.

1. Imagine that you dropped a penny from the Empire State Building (please, never do it in real life!). Calculate the speed of the coin in 5 seconds.

2. Explain (and make a scheme) what happens to a pebble if you throw it vertically up?

3. a) Tesla's Model S Performance is the fastest-accelerating production car. It reaches 60 mph in just 2.4 seconds. Find its acceleration and compare it to the free fall acceleration on Earth, g.

b) Now assume that after traveling with this speed the car starts braking with acceleration 4 m/s^2. How long would it take to stop?

4. A ball with zero initial velocity falls down from a height of 5m and hits the ground in 1 second. Find average velocity of the ball and compare it to the velocities of the ball in the beginning and in the end of the motion.