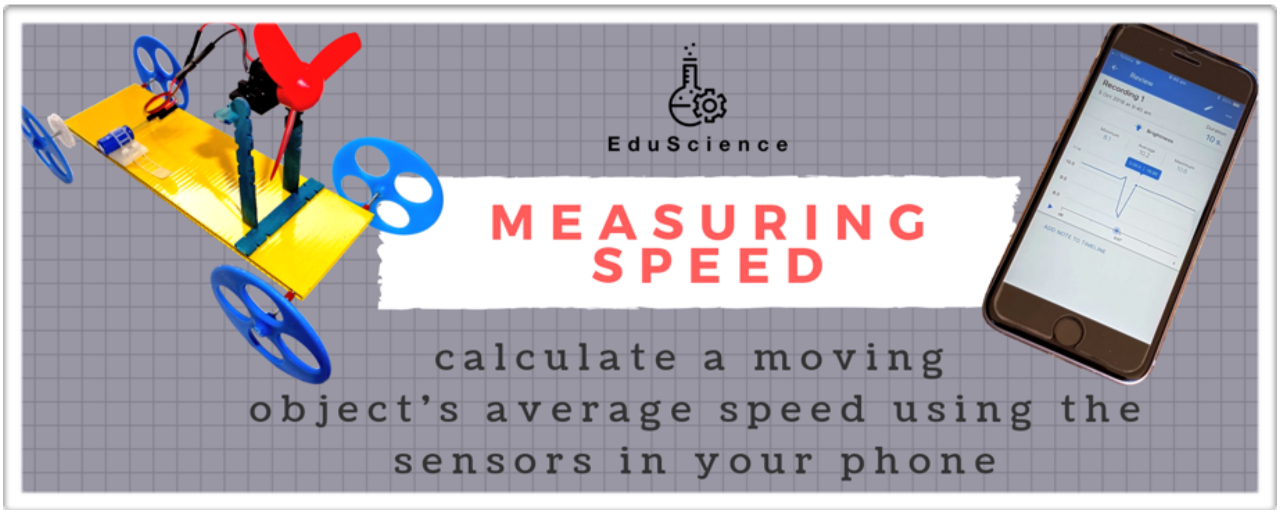
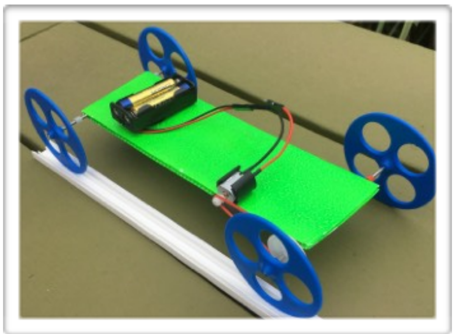



Measuring the average speed of a moving object can be very useful, especially when analysing the impact of design changes in engineering. This is helpful for OneCar too where you may have various car designs in one classroom and require a way to differentiate between the designs.

Now, how do we easily measure average speed? Do you need electronic time gates or sonar equipment? No! Our smartphones come packed with useful sensors that can be utilised in the science laboratory. Some of the useful sensors in your phone are: accelerometer, linear accelerometer, gyroscope, light sensor, microphone, magnetometer, geospatial sensor, barometer and a camera. In this article we will focus on using two of these sensors to determine the average speed of OneCar, our moving object.

To recap the basics: The average **speed** is a *scalar* quantity and is the total distance travelled by the object divided by the elapsed time to cover the distance. It is the distance per time ratio. On the other hand, average **velocity** is a *vector* quantity, which uses displacement and direction, and may even be zero if you end up where you started!

*Classroom set-up tip:*
*To determine the average speed of a moving object, you have to make the object run in a straight line. We found that one half of a plastic* ***data cable channel*** *acted as a perfect guide for OneCar's wheels. (These channels are available from electrical distributors & hardware stores).*



Let's get going with the standard classical method used for ages.

## A. The classic Tape-and-Time method

1. Determine the travel distance (d) on the track using a tape measure
2. Determine the time (t) using a stopwatch / timer
3. Divide the distance travelled by the time spent travelling
4. Make at least three time observations and calculate the average speed

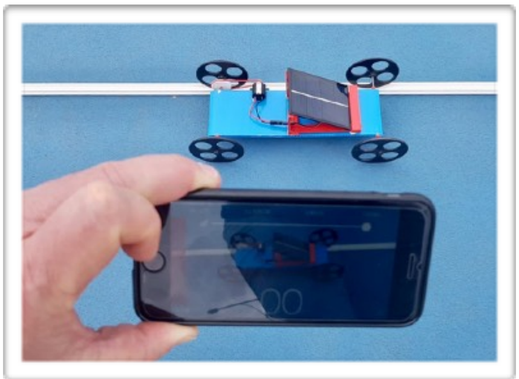
$$S = \frac{d}{t}$$

where S is the average speed, d the total distance travelled and t the time travelled

## B. SpeedClock: Mobile phone app for iOS devices

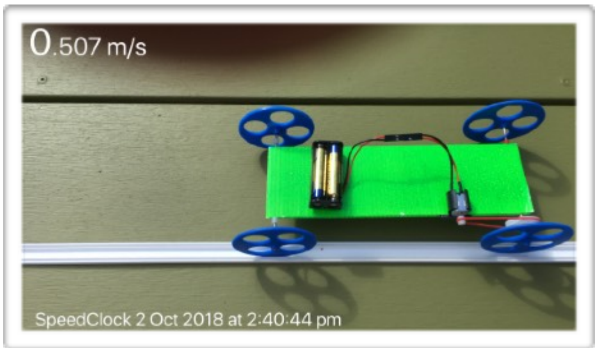
In this method we will use the camera in the mobile phone to record the speed of OneCar.
Download the app: "SpeedClock"
It is only available for iOS devices at a cost of USD3.00 (No, we do not get a commission!)
Visit https://appmaker.se/speedclock

This app easily measures the speed of a moving object such as a car, rolling ball or projectile. It only requires one reference dimension to calculate the speed. This can be the distance to the moving object or a dimension on the object such as the diameter of a wheel. You simply hold the phone steady and let the object run pass the screen. The average speed will be displayed on the screen and you can even record a snapshot or take a video of the motion.



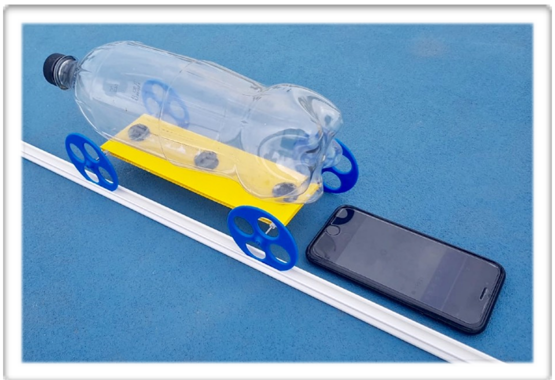
SpeedClock offers 3 methods of speed detection:
The **SpeedM** option should provide satisfactory results in the lab for slow moving objects and is easy to use. **SpeedV** records a video and is ideal for faster moving objects such as small projectiles. **SpeedR** utilises two phones set apart at a known distance, and connected via Bluetooth to act as two "time gates".

Below are the app images of speed measurements that were done with the OneCar solar car (blue) and battery car (green):

## C. Google's Science Journal app

The Science Journal app turns your phone into a pocket science lab using the existing built-in sensors of the phone. Science Journal is a Google education initiative and is free, running on the iOS and Android platforms.
Visit https://sciencejournal.withgoogle.com/ Students can use the app as a journal to document projects using notes, photos and the phone sensors.



In this measurement we use the **light sensor** of the mobile phone and a light source (lamp or sunlight). Simply start the light intensity recording on the phone and place the phone **face-up** next to the car track. OneCar has enough clearance to move over the phone while the phone is recording the light levels. The resultant graph on your phone should be similar to this:


The x-axis shows time in minutes:seconds [min:s] and the y-axis is light intensity in lux.

1. Use a ruler to measure the length of the car body that blocks the light (in meter). This is the distance, d.
2. The light sensor readings act as "time gates" so you can calculate the travel time, t, for the car over distance, d. The time difference between the drop and increase of the light readings will give the travel time. Expand the view on your phone to make the readings.
3. Here are our results: BatteryCar: S = (0.20m)/(0.4s) = 0.5m/s
   AirCar: S = (0.20m)/(0.2s) = 1.0m/s

$$S = \frac{d}{t}$$

*Reference source for method: https://www.sciencebuddies.org*

Most other motion apps require your phone to be mounted on the moving car. This will unfortunately slow it down, but if you have a more powerful car or projectile, try it out!

A valuable and interesting site of note is https://phyphox.org/ with many well-documented experiments for the classroom. "Use your smartphone as a mobile lab", developed by RWT Aachen University in Germany).

Have fun!
OneCar Team