Boğaziçi University

Introductory Phys Labs

FORCE AND ACCELERATION

PHYL 101

THEORY

Newton's First Law of Motion states,

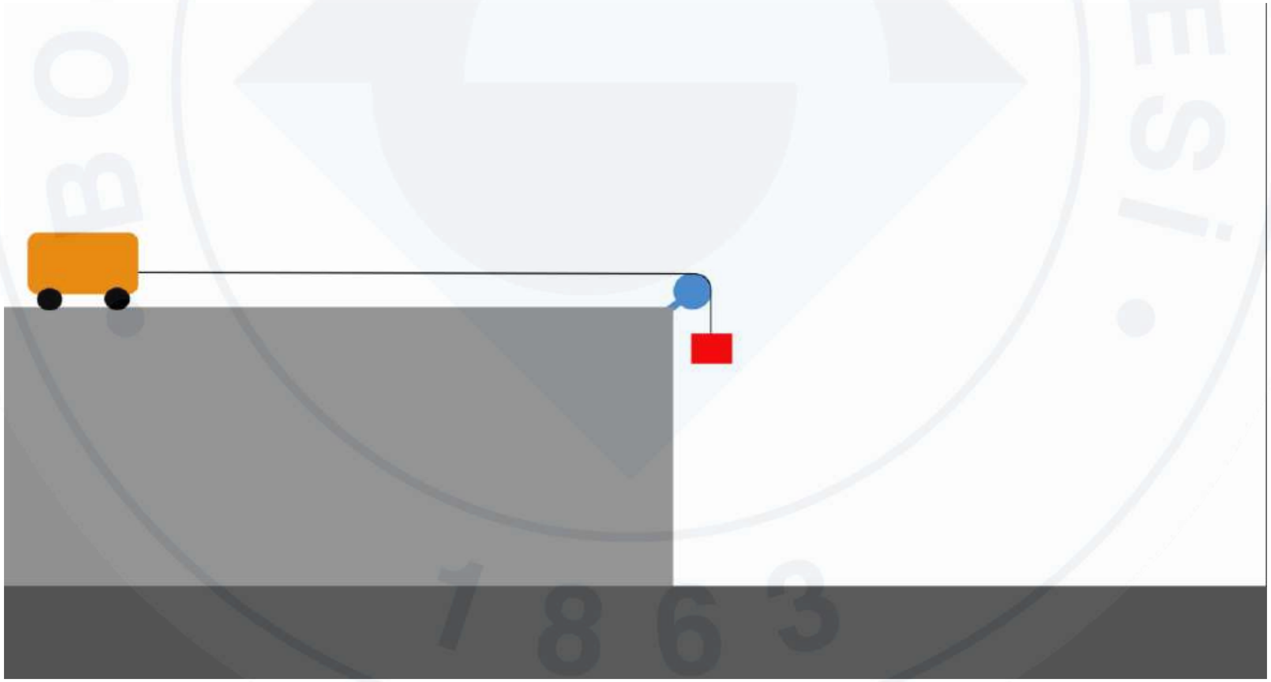
"A body at rest will remain at rest, and a body in motion will remain in motion unless it is acted upon by an external force."

What, then, happens to a body when an external force is applied to it? That situation is described by Newton's Second Law of Motion.

Isaac Newton's First Law of Motion states,

"A body at rest will remain at rest, and a body in motion will remain in motion with constant velocity unless it is acted upon by an external force."

What, then, happens to a body when an external force is applied to it? That situation is described by Newton's Second Law of Motion.



Newton's second law says that when a force acts on a massive body, it causes it to accelerate, i.e., to change its velocity; and when this force is constant the acceleration is constant as well. A force applied to an object at rest causes it to accelerate in the direction of the force.

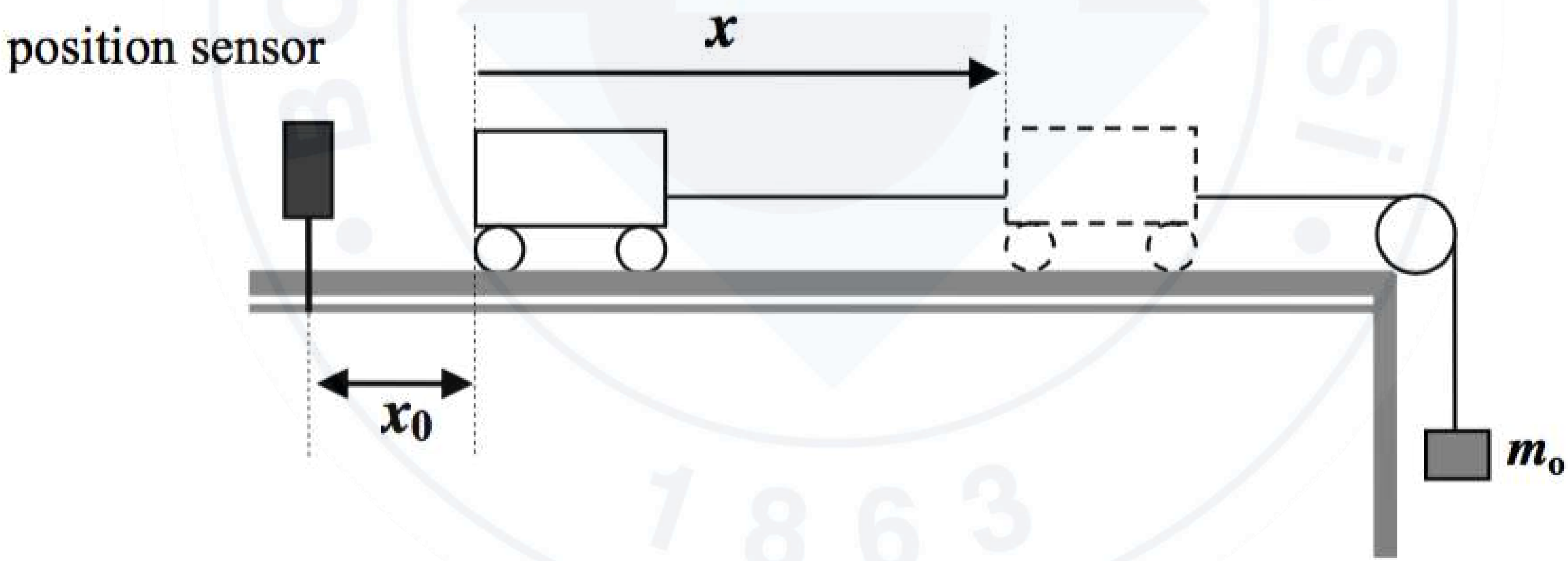
The direction of force and acceleration vectors can be taken into account by using *x* and *y* components.

$$\sum \vec{\mathbf{F}} = m\vec{\mathbf{a}}$$

is equivalent to

$$\sum F_y = ma_y \qquad \sum F_x = ma_x$$

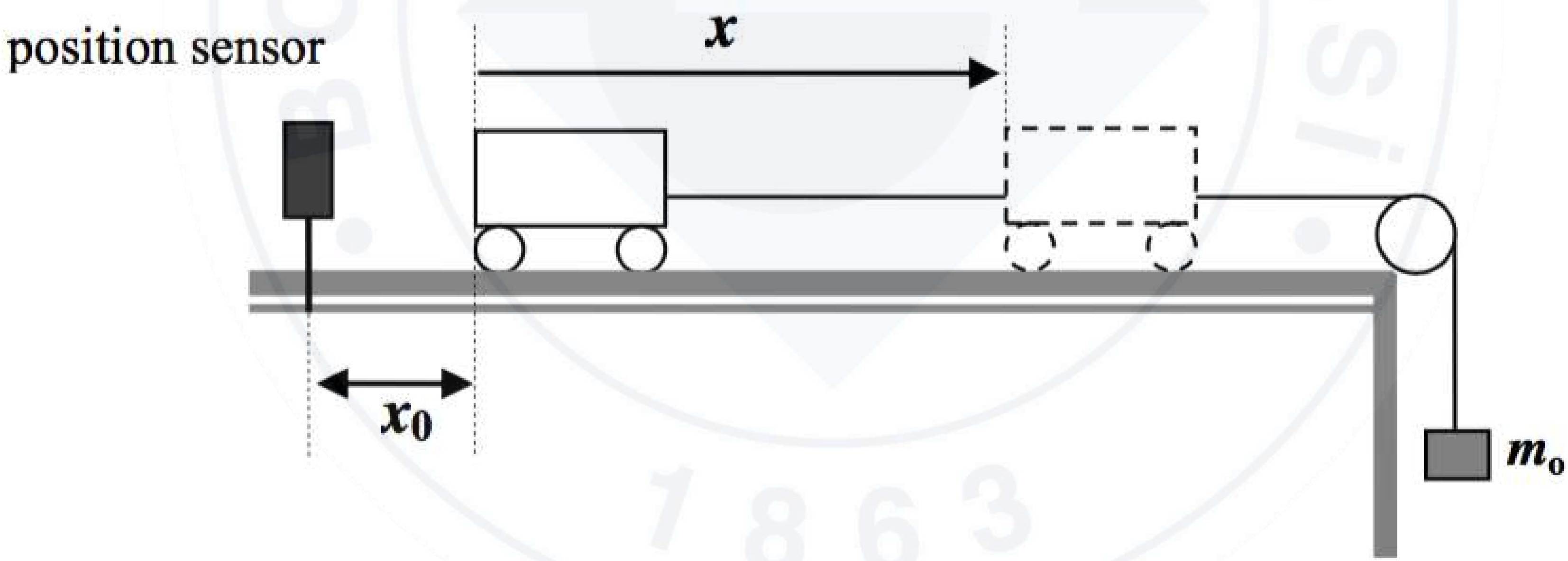
In this experiment, the motion of the car on a special track is studied. Masses are placed on the mass holder that is attached to the car. When the masses are released, they fall to the floor while applying a force on the car due to gravitation.



What to measure (sensor + data logger) : Position of the car, x(t)

What to calculate : Acceleration of the car, a(t)

Experimental findings : Mass of the car , m_{CAR}



Acceleration of the car can be calculated from the Newton's Law:

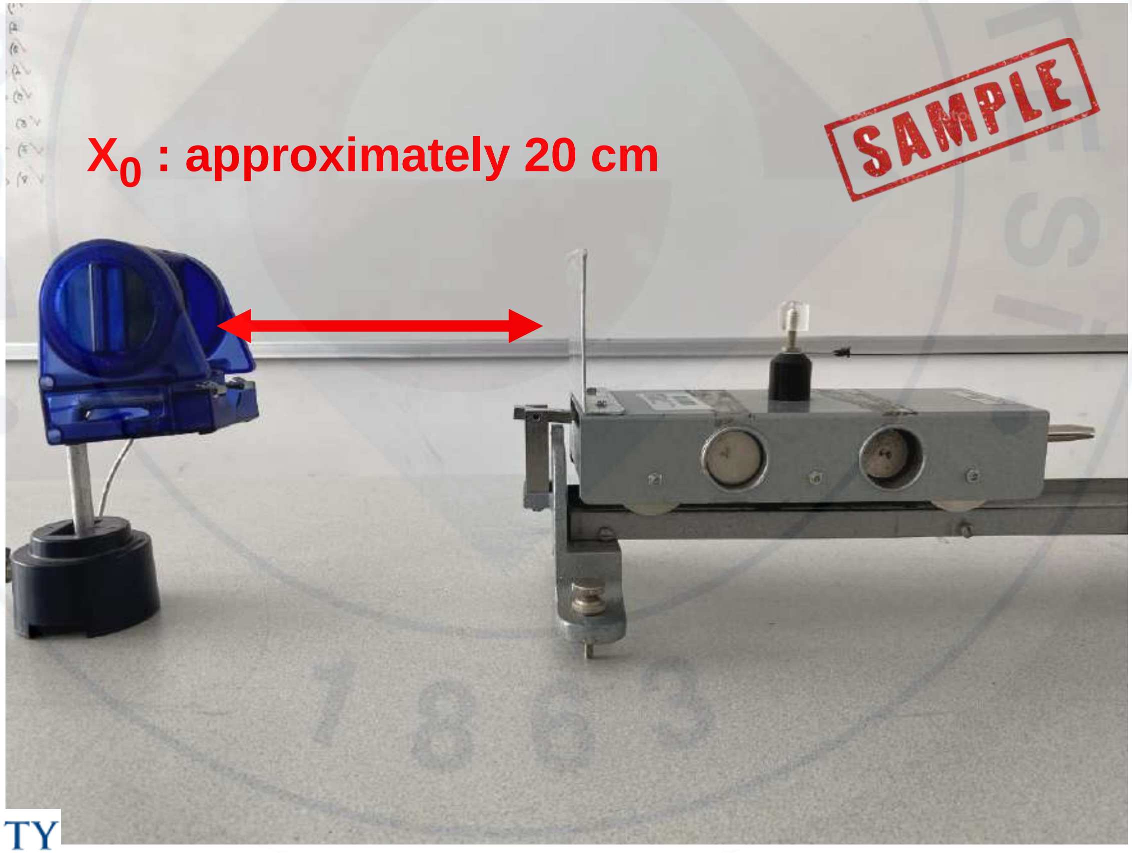
$$M_{total} a = m_o g$$

$$a = \frac{m_o}{M_{total}} g$$

$$M_{total} = m_c + m_0$$

APPARATUS

Position of the car is detected with the help of a position sensor. The sensor works by sending ultrasound pulses forward and listening for the echoes. From the known speed of sound in the air and the time between the transmission and reception of the ultrasound signals, the data logger determines the distance to the sensor.



You will record the number of cylinders used in your experiment.

0 CYLINDER

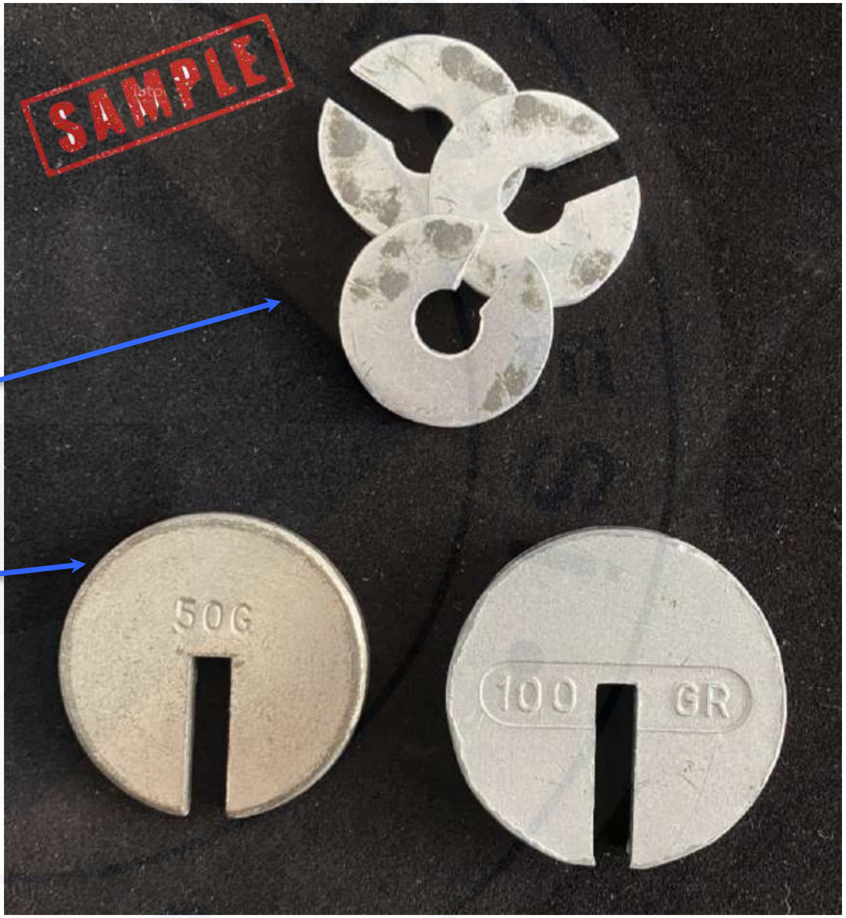
2 CYLINDERS

1 CYLINDER

Position sensor is set approximately 20 cm away from the car before releasing it.

Data logger is adjusted the to an appropriate rate, 10 per second and the friction force is compensated by using a few washers.

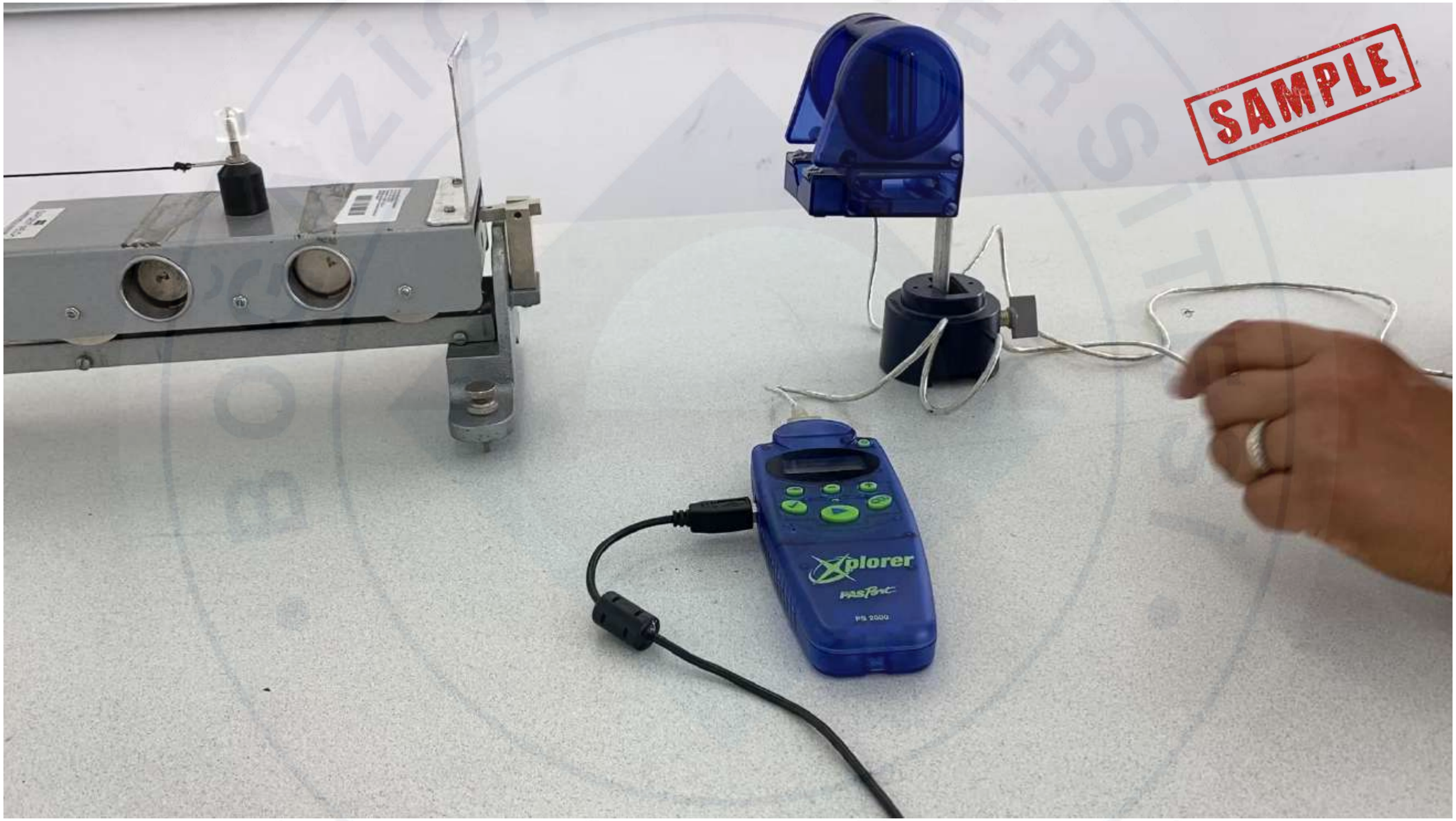
Given masses are placed on the holder. The data logger is started and the car is released. Data logger is stopped when the mass holder hits the ground.



EXPERIMENT

BE CAREFUL ! ALL THE DATA USED THROUGHOUT THIS PRESENTATION IS JUST A SAMPLE AND NOT TO BE USED FOR YOUR EXPERIMENT REPORT.

YOU WILL "MEASURE" YOUR OWN EXPERIMENTAL DATA IN THE LAB.



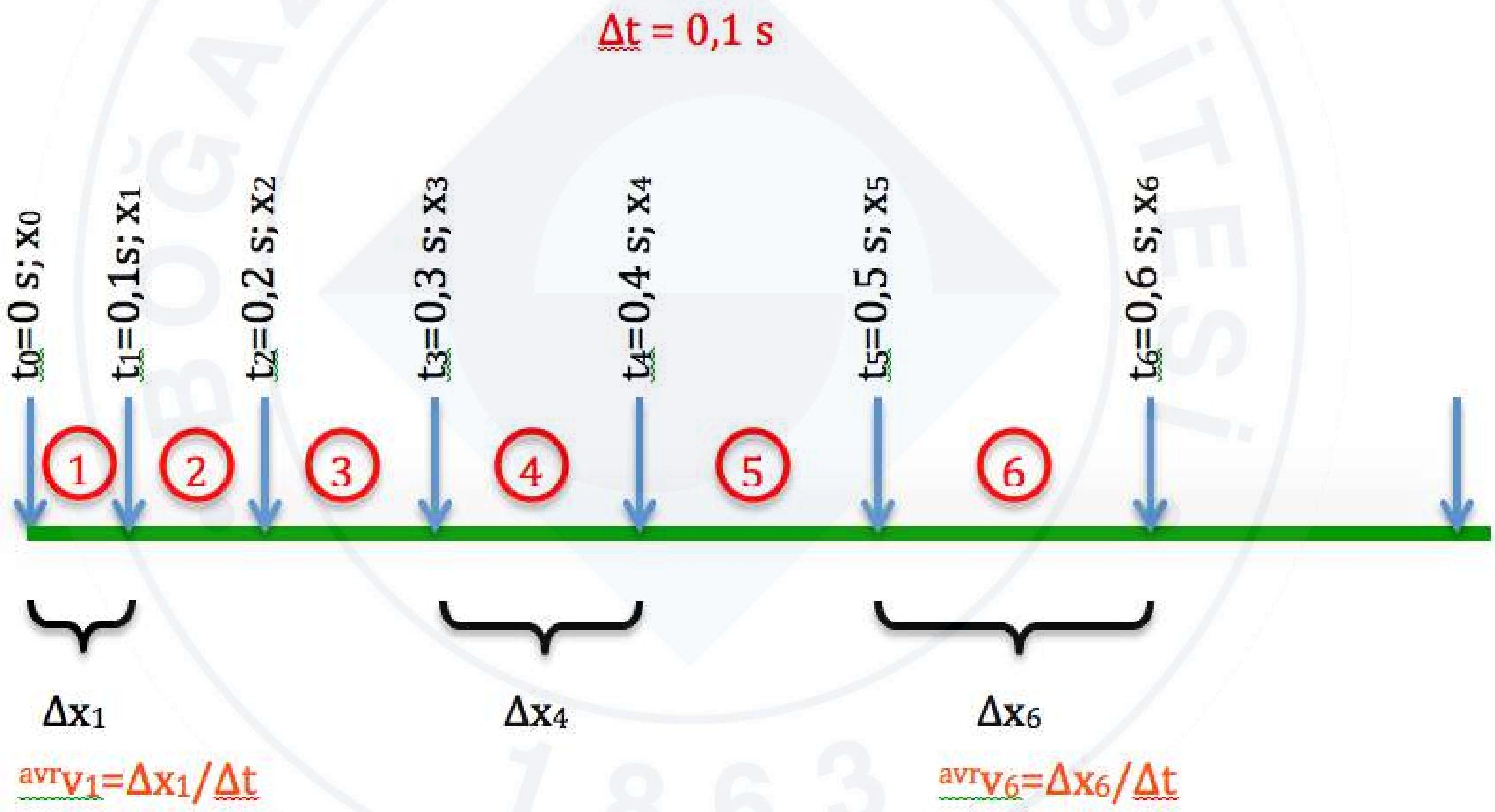
VIDEO 1

Data Logger is attached to the position sensor and it records the position of the car at 0,1 s intervals.

The first few data values will be unchanged because although Data Logger collects the data, car is not released yet.

Last few data values are also unchanged because car hits the end of the path and it is not moving anymore.

The path of the car and data taken from the Data Logger.



To measure the acceleration we have to record the motion of the (mass + car) system as a function of time.

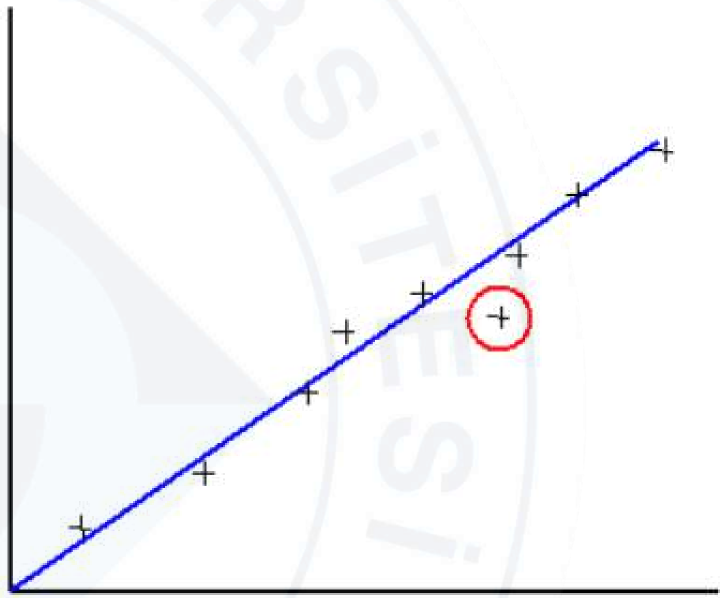
The velocity is the derivative of the position and the acceleration is the derivative of the velocity with respect to the time.

We can only determine the position at specific times. Even though the velocity and the acceleration may not be constant, we can still determine the average velocity for a specific interval.

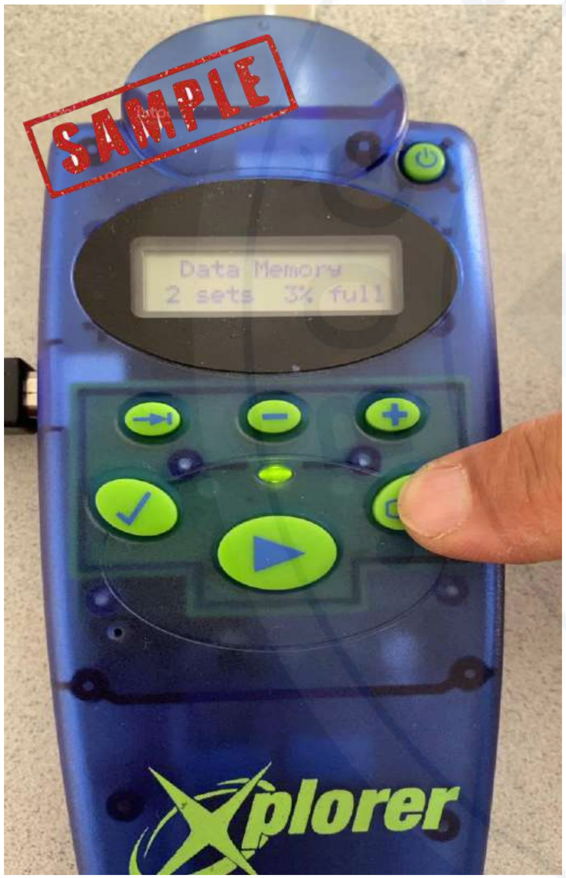
$$V_{average} = \Delta x / \Delta t$$

From the plot of the average velocity versus the time we can determine the acceleration by taking the derivative of the function defined by this graph.

Lastly, there could be anomalous points in the readings of the position sensor that could be resulted from some experimental errors. Note such points (if there is any) on your average velocity vs. time graph and treat them accordingly while you are calculating the slope.



Note the Position (x)-data (2^{nd} column) from the data logger.



Number of Intervals	t ( )	x ( )	Δx ( )	$V_{avg} = \Delta x / \Delta t$ ( )

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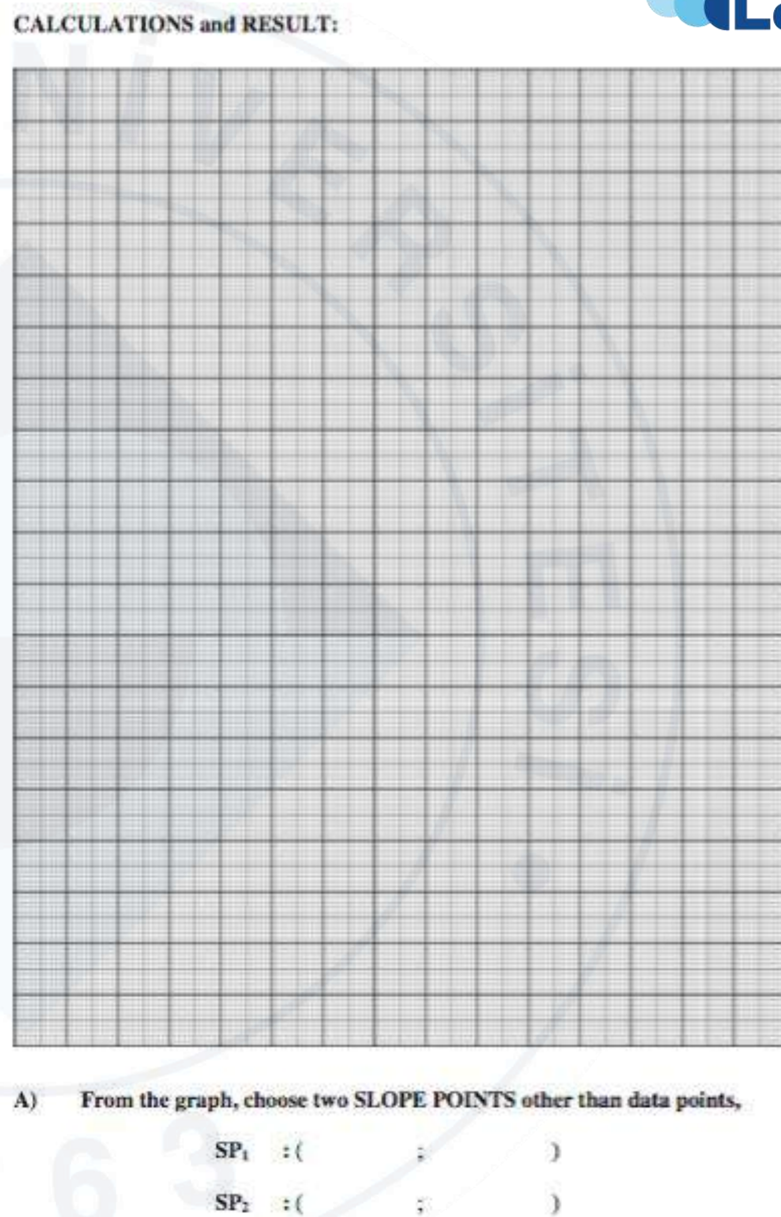
- **On the given graph paper, plot the average velocity versus time.**
- **Choose two points to calculate the slope of the best fit line.**
- **Calculate slope.**
- **Determine the acceleration.**

Scale your axes in such a way that your graph fills the whole paper. Otherwise your scaling will be wrong.


CALCULATIONS and RESULT:

A) **From the graph, choose two SLOPE POINTS other than data points,**

SP_1 :(;)

SP_2 :(;)

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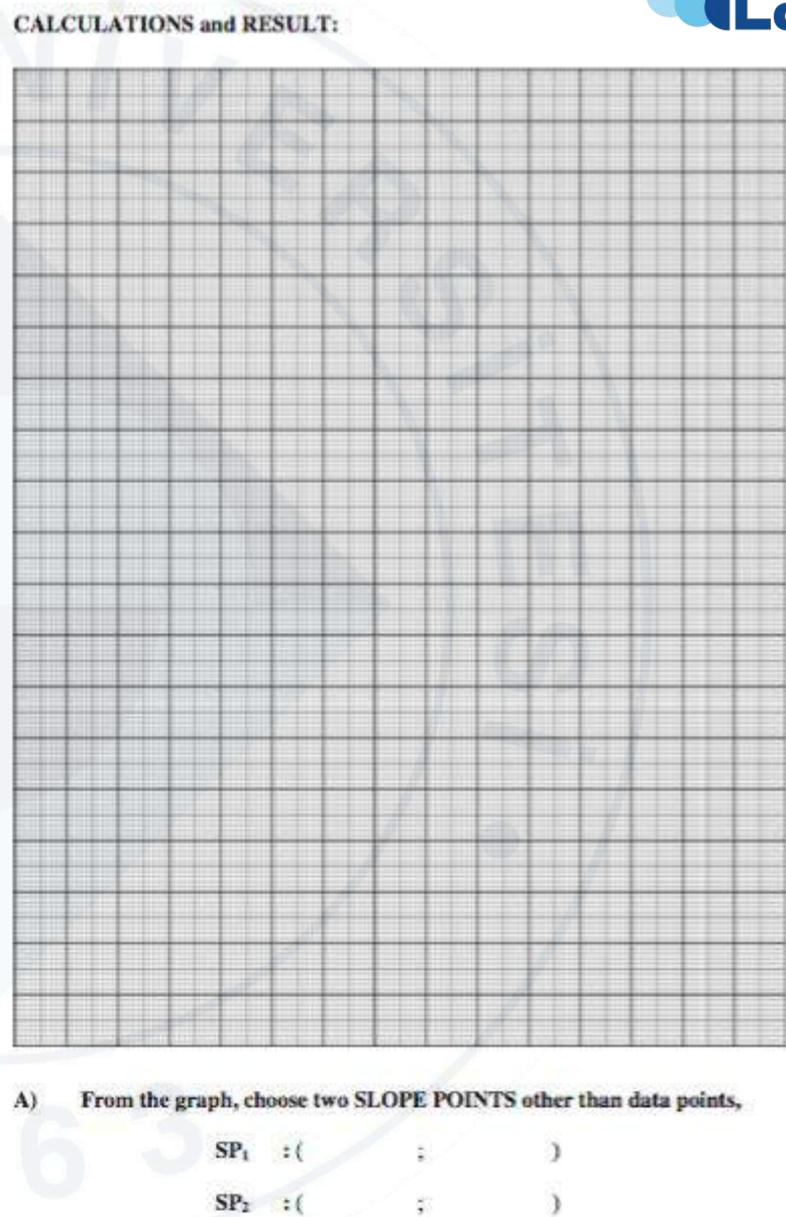
- How to Plot your Graph :
- Label your Axes and
- specify the units :
- “V_{av} (m/sec) – t (sec)”
- Take the first-15 data if you have more than that.
- Scale your axes properly and make sure that you are using the whole of your graph page.


CALCULATIONS and RESULT:

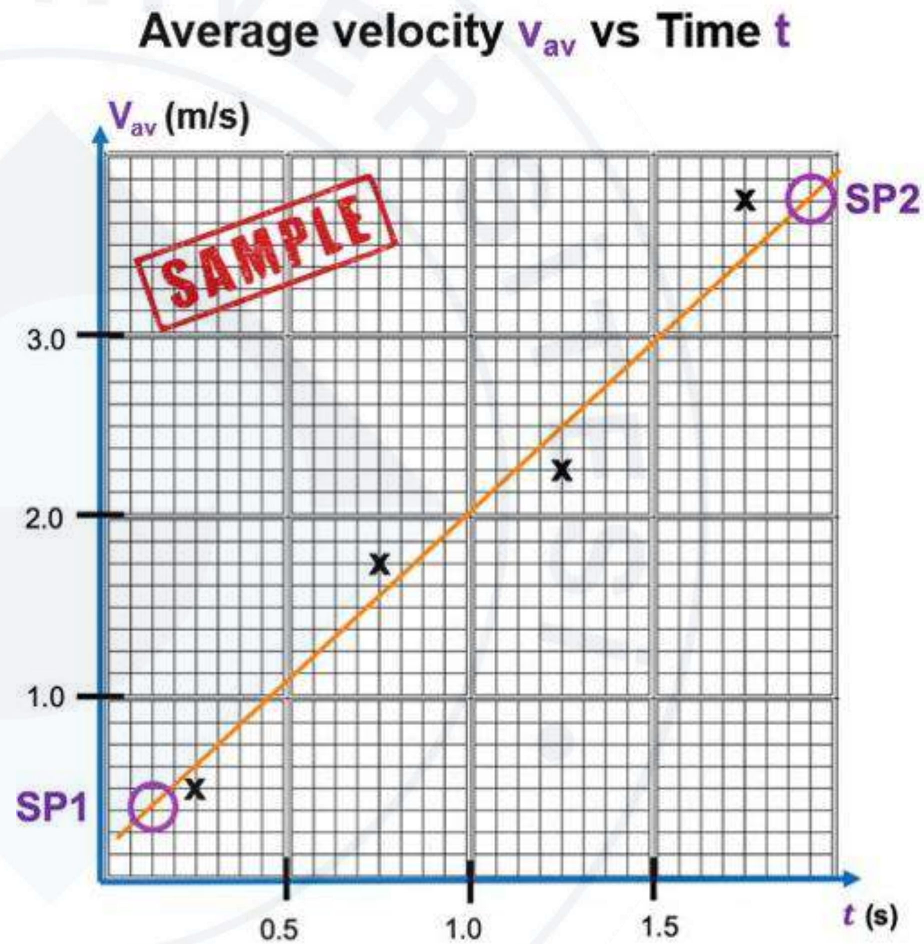
A) From the graph, choose two SLOPE POINTS other than data points,

SP_1 : (;)

SP_2 : (;)

How to Plot your Graph :

- **Note that each average velocity value should be matched with the mid-point of the corresponding time interval.**
- **See the example. Recall that each time interval lasts 0.1 seconds. Hence, average velocity values v_1 , v_2 , and v_3 are matched to t = 0.25, 0.75, 1.25 sec, etc., respectively.**



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- Fill the empty spaces
- accordingly.

- Acceleration equals the "slope".
- Determine total mass and mass of the car.
- Finally, answer the questions at the end of the experiment.

B) By using SP_1 and SP_2, calculate:

Description / Symbol		Calculations (show each step)	Result
SLOPE	=	....	....
		....	
Acceleration a	=	....	....
Total Mass M_{total}	=	....	....
		....	
Mass of the Car m_c	=	....	....
		....	