Boğaziçi University

Introductory Phys Labs

PROJECTILE MOTION

PHYL 101

THEORY

PROJECTILE MOTION

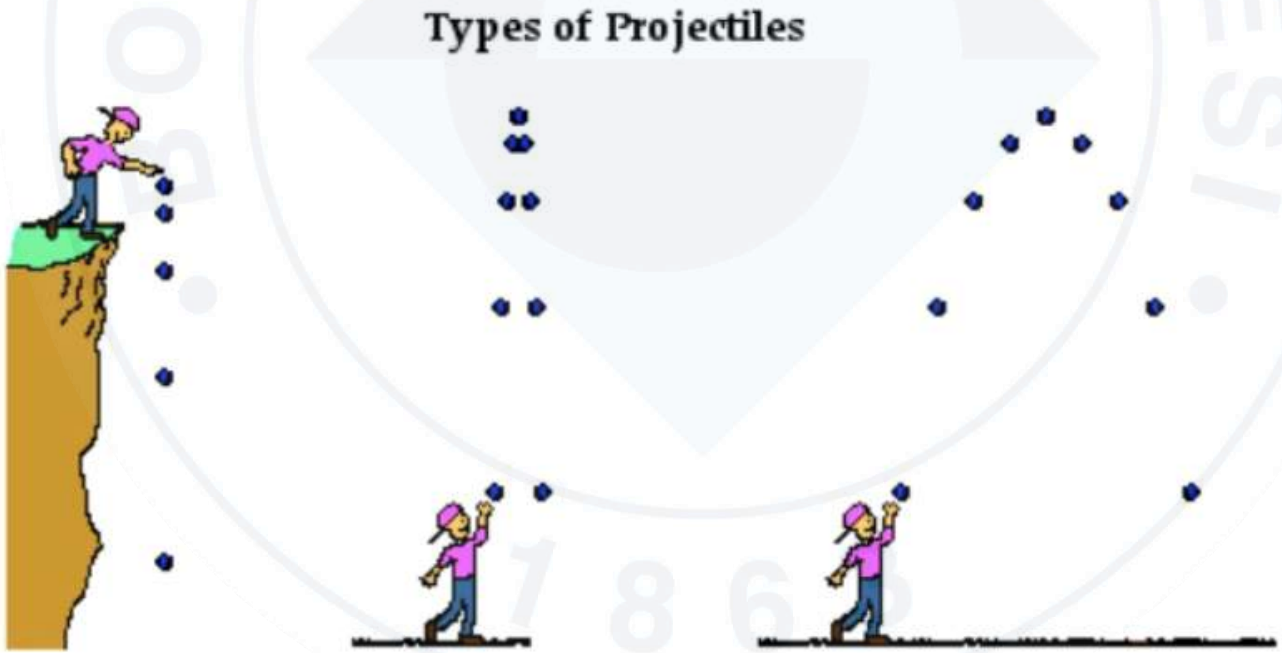
Projectile motion is a form of motion experienced by an object or particle (a projectile) that is projected near the Earth's surface and moves along a curved path under the action of gravity only.

(in particular, the effects of air resistance are assumed to be negligible)

PROJECTILE MOTION

For example, you throw the ball straight upward, or you kick a ball and give it a speed at an angle to the horizontal or you just drop things and make them free fall; all these are examples of projectile motion.

In projectile motion, gravity is the only force acting on the object.



PROJECTILE MOTION

In a Projectile Motion, there are two simultaneous independent rectilinear motions:

Along x-axis:

uniform velocity, responsible for the horizontal (forward) motion of the particle.

Along y-axis:

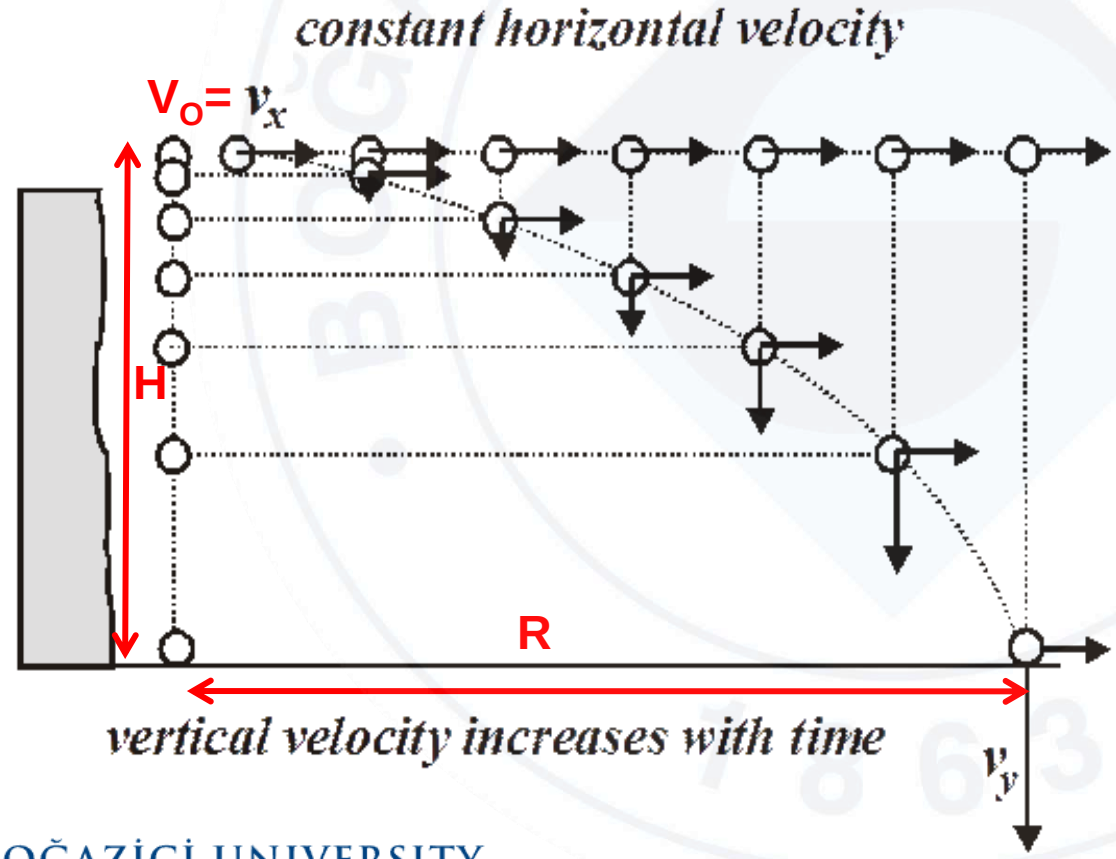
uniform acceleration, responsible for the vertical (downwards) motion of the particle.

Accelerations in the horizontal projectile motion and vertical projectile motion of a particle: When a particle is projected in the air with some speed, the only force acting on it during its time in the air is the acceleration due to gravity (g). This acceleration acts vertically downward. There is no acceleration in the horizontal direction which means that the velocity of the particle in the horizontal direction remains constant.

HORIZONTAL MOTION

Horizontal velocity component is always constant

There is no acceleration in the *horizontal direction*.



$$R = v_0 t$$

$$H = \frac{1}{2} g t^2$$

$$v_o = R\sqrt{\frac{g}{2H}}$$

APPARATUS

PROJECTILE MOTION

BALLISTIC PENDULUM – SPRING GUN

SHORT RANGE

MEDIUM RANGE

USE THE SAME RANGE IN THE BOTH PARTS OF THE EXPERIMENT !!

EXPERIMENT

PART 1 - HORIZONTAL MOTION

PROJECTILE MOTION

What to measure (ruler) : **Range of the Motion, R.**

Height of the ball, H.

Experimental Findings : **Initial velocity of the ball, v_0 .**

PROJECTILE MOTION

PART 1 - HORIZONTAL MOTION: Spring Gun (set to Short or Medium Range)

The spring gun is leveled on the table and the plastic ball is projected horizontally. The initial velocity of the ball is determined by measuring the range (R) of the motion, and the initial height (H) of the ball.

PART 1 - HORIZONTAL MOTION: **Ball hits on the carbon paper and leaves a spot on the white paper below carbon paper. The range of the motion is measured. It is repeated 3 times and the average value is taken.**

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

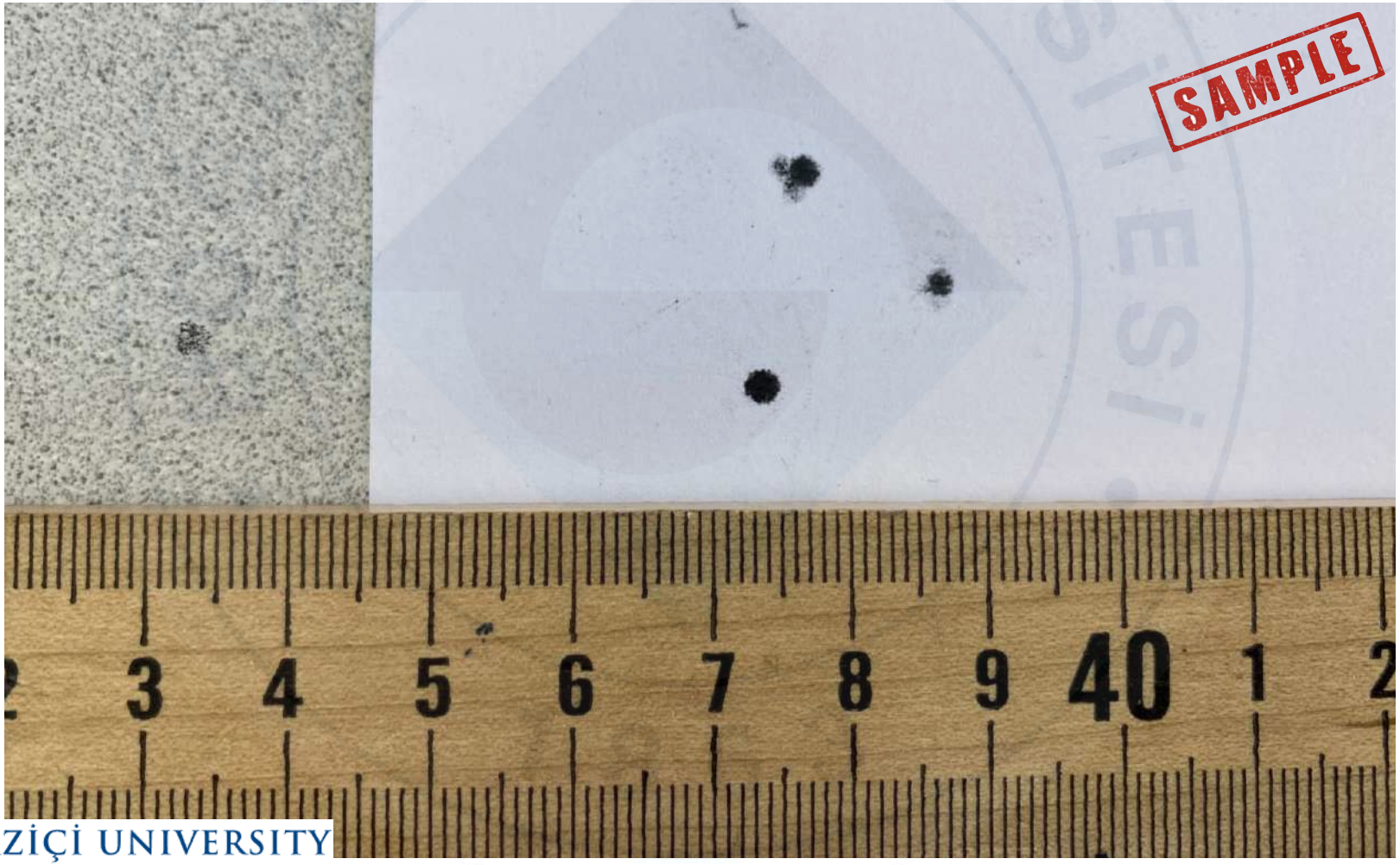
YOU WILL "MEASURE" YOUR OWN EXPERIMENTAL DATA IN THE LAB.

PROJECTILE MOTION

Height of the ball is measured from the table surface to the launch point of the ball.

How to measure the range of the motion :

Three measurement data will be taken from the black spots on the paper.



Use the below data to calculate the velocity of the ball, v_0, and make sure you specify which range the spring gun is set to.

INCLUDE THIS IN YOUR DATA !!

PART 1 – HORIZONTAL MOTION

Description / Symbol			Value & Unit	# of Significant Figures
RANGE OF THE GUN :				
Height	H	=	.....	.....
Range (1st trial)	R_1	=	.....	.....
Range (2nd trial)	R_2	=	.....	.....
Range (3rd trial)	R_3	=	.....	.....
Average Range	R_{ave}	=	.....	.....

PART 2 – PROJECTILE MOTION

PROJECTILE MOTION

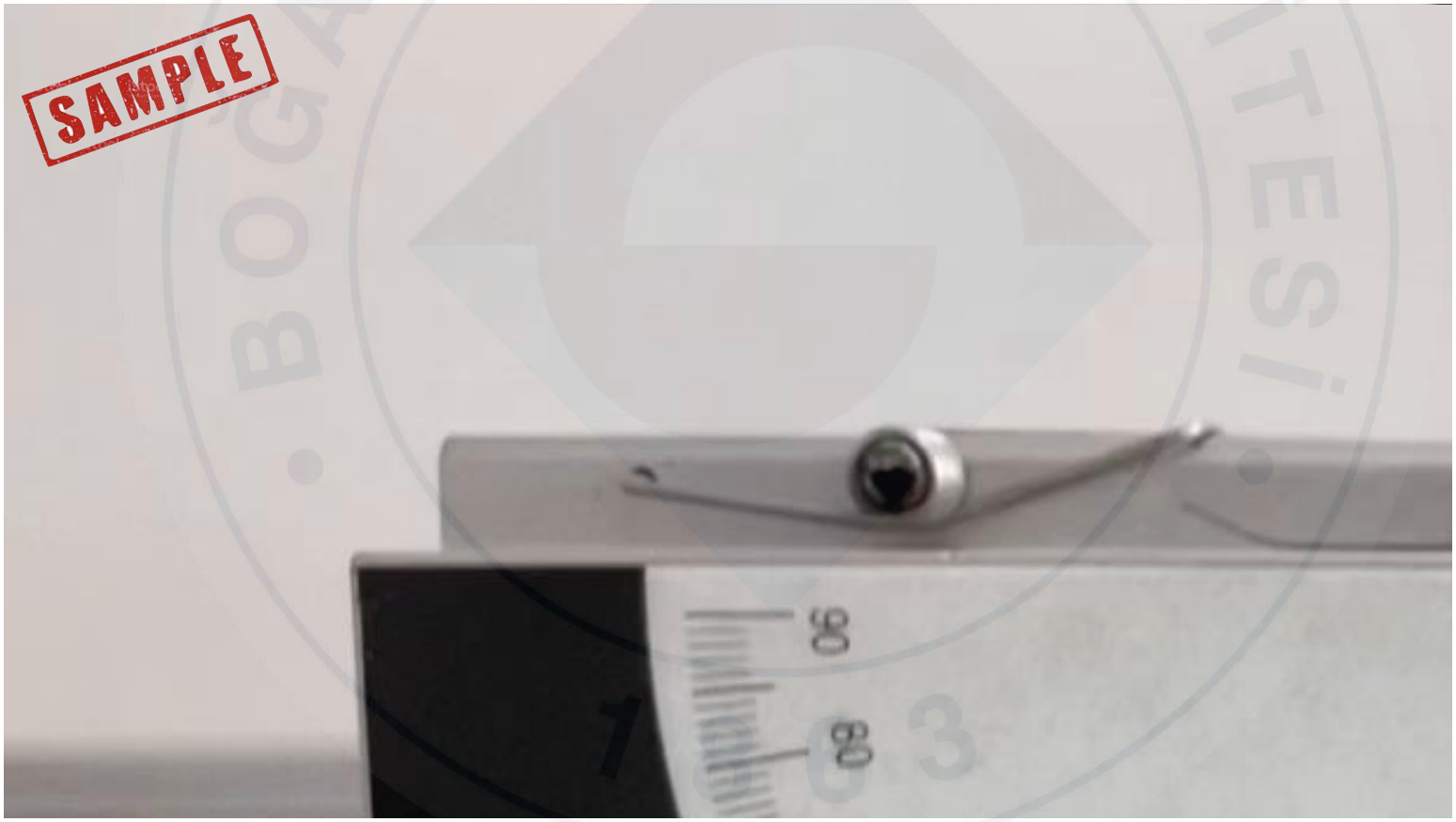
What to measure (ruler) : **Range of the Motion, R.**

Height of the ball, H.

What to calculate : Tangent of projection angle, tan(θ).

Experimental Findings : Projection angle.

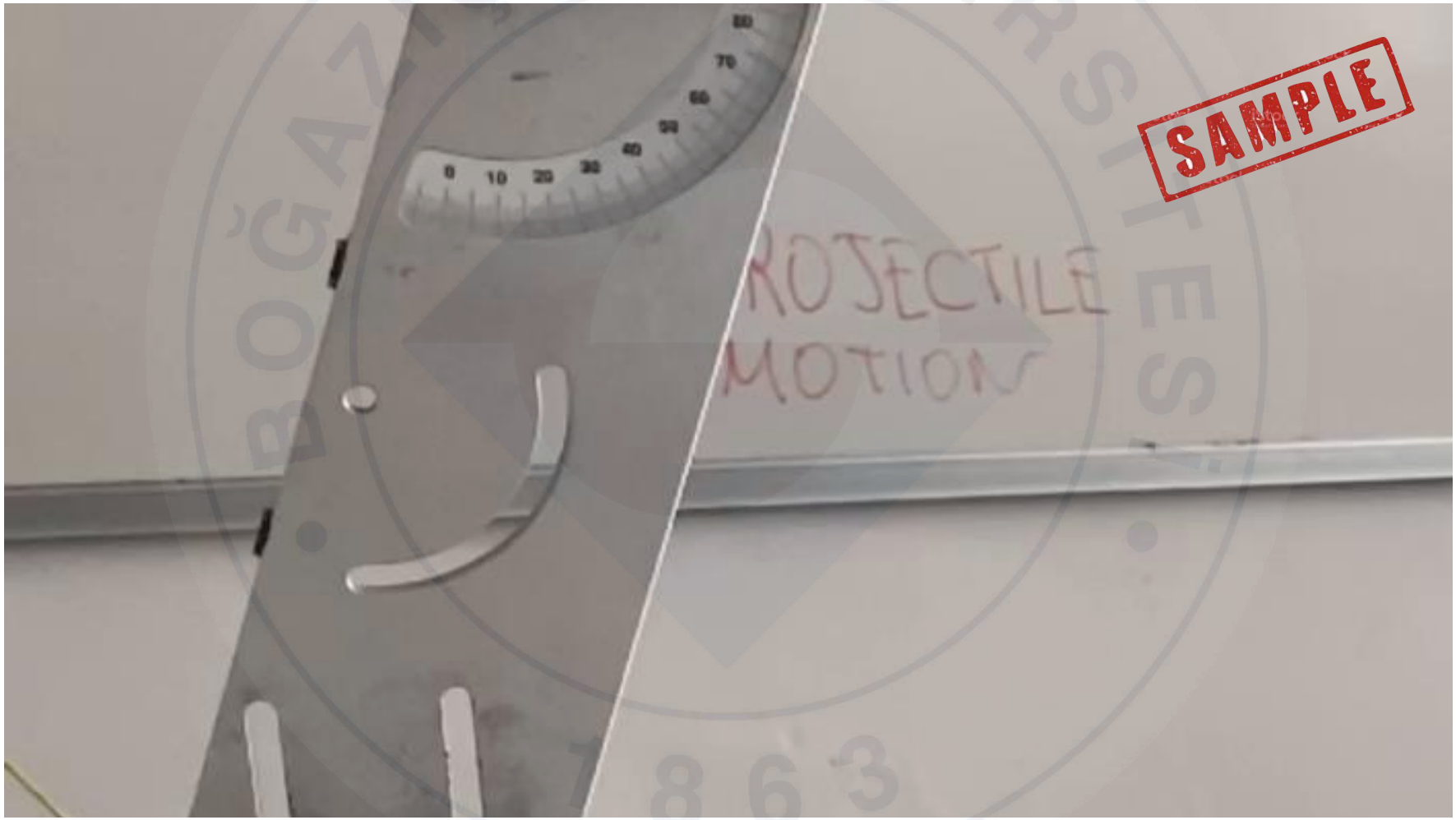
PART 2 - PROJECTILE MOTION : The spring gun is inclined at an angle Θ with the horizontal and the ball is shot freely. Range, height and the initial velocity of the ball are used to calculate Θ.



Range of the gun is set to the same one used in Part-1.

VIDEO -5

PROJECTILE MOTION



PROJECTILE MOTION

Same range used in Part-1 is set for the spring gun.

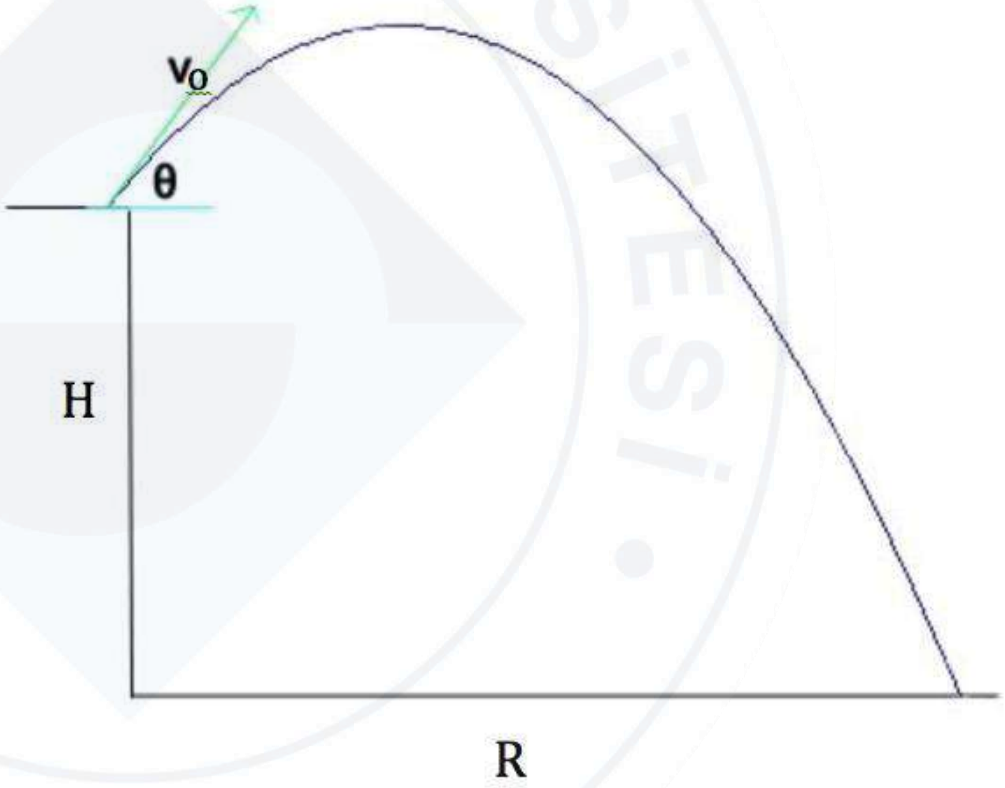
V_0 is known from Horizontal Motion part.

$$v_x = v_0 \cos(\theta),$$
$$v_y = v_0 \sin(\theta) - gt.$$

$$v = \sqrt{v_x^2 + v_y^2}$$

$$x = v_0 t \cos(\theta),$$
$$y = v_0 t \sin(\theta) - \frac{1}{2} g t^2$$

$$y = \tan(\theta) \cdot x - \frac{g}{2 v_0^2 \cos^2 \theta} \cdot x^2$$



It can be shown that the trajectory equation is:

$$\frac{gR^2}{2v_o^2}\tan^2\theta - R\tan\theta + \left(\frac{gR^2}{2v_o^2} - H\right) = 0$$

θ is unknown. Solve this 2nd order equation, find the roots for θ.
There are two θs satisfying this trajectory equation for the same H and R.

This equation looks like $a\,x^2 + b\,x + c = 0$ where :

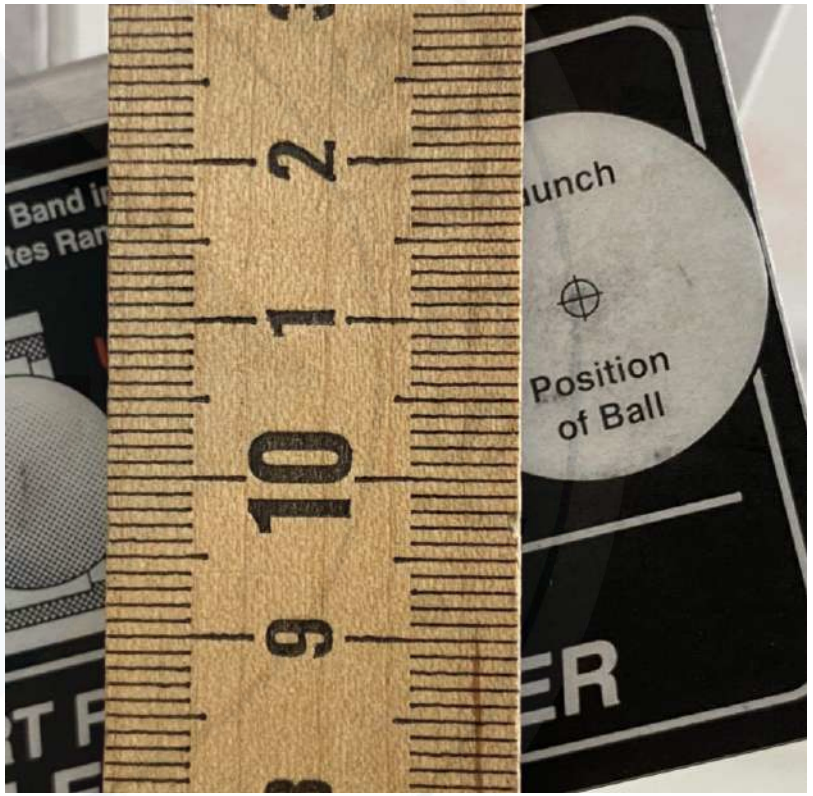
$x = \tan\theta$, $a = gR^2 / 2v_0^2$, $b = -R$, $c = (gR^2 / 2v_0^2) - H$.

Roots are given by :

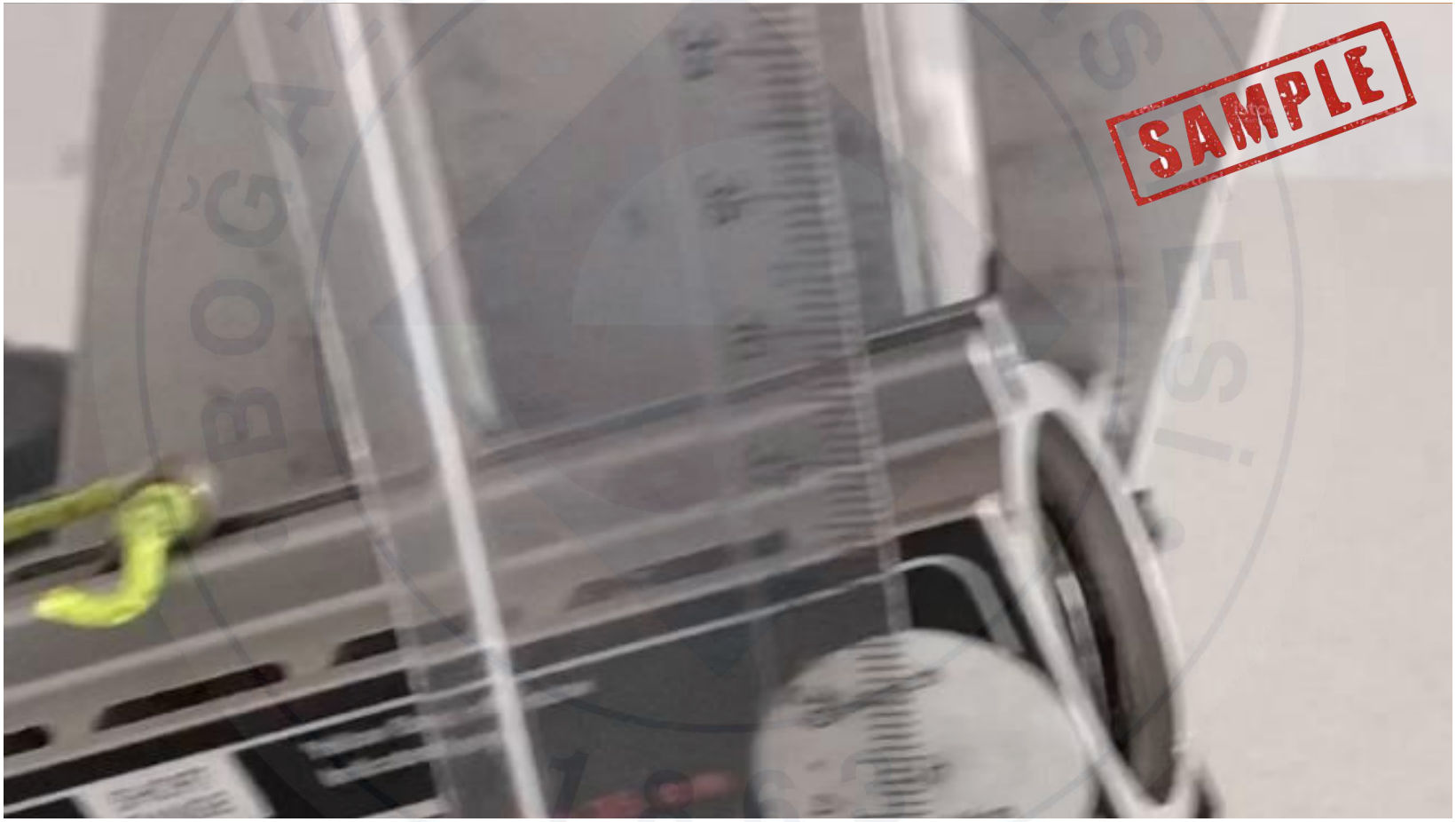
$$x_+ = \frac{-b + \sqrt{b^2 - 4ac}}{2a},$$

$$x_- = \frac{-b - \sqrt{b^2 - 4ac}}{2a}.$$

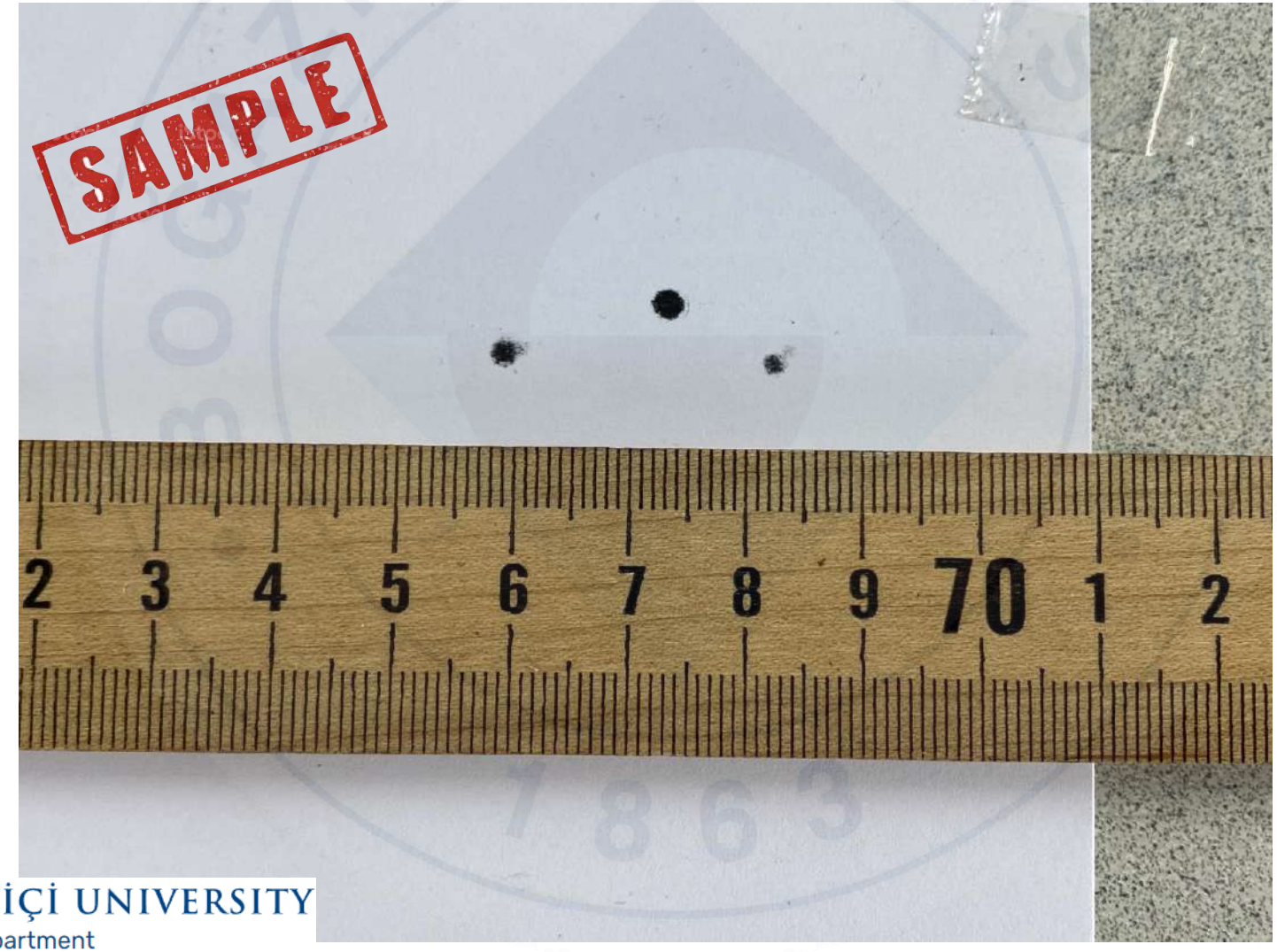
Height of the ball is measured from the table surface to the launch point of the ball.



How to measure the Range of the Motion :



Three measurement data are taken from the black spots on the paper.



Fill in the empty spaces accordingly.

PART 2 – PROJECTILE MOTION

Description and Symbol			Value & Unit	# of Significant Figures
Height	H	=	.....	.....
Range (1st trial)	R_1	=	.....	.....
Range (2nd trial)	R_2	=	.....	.....
Range (3rd trial)	R_3	=	.....	.....
Average Range	R_{ave}	=	.....	.....
Measured Angle	θ_{MV}	=	.....	.....

Use this data and v_0 from Part-1 to calculate the $\tan\theta_1$ and $\tan\theta_2$.