Boğaziçi University

Introductory Phys Labs

BALLISTIC PENDULUM

CONSERVATION OF MOMENTUM

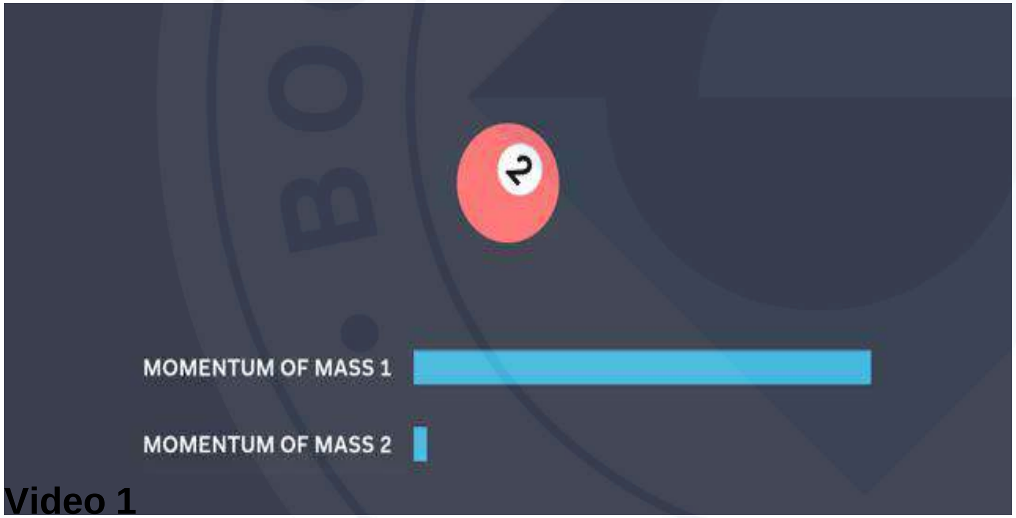
PHYL 101

THEORY

PhysLabs

One of the most powerful laws in physics is the conservation of momentum.

For a between two objects in an isolated system, the total momentum of the two objects before the collision is equal to the total momentum of the two objects after the collision. That is, the momentum lost by object 1 is equal to the momentum gained by object 2.



Video 1

Before the collision

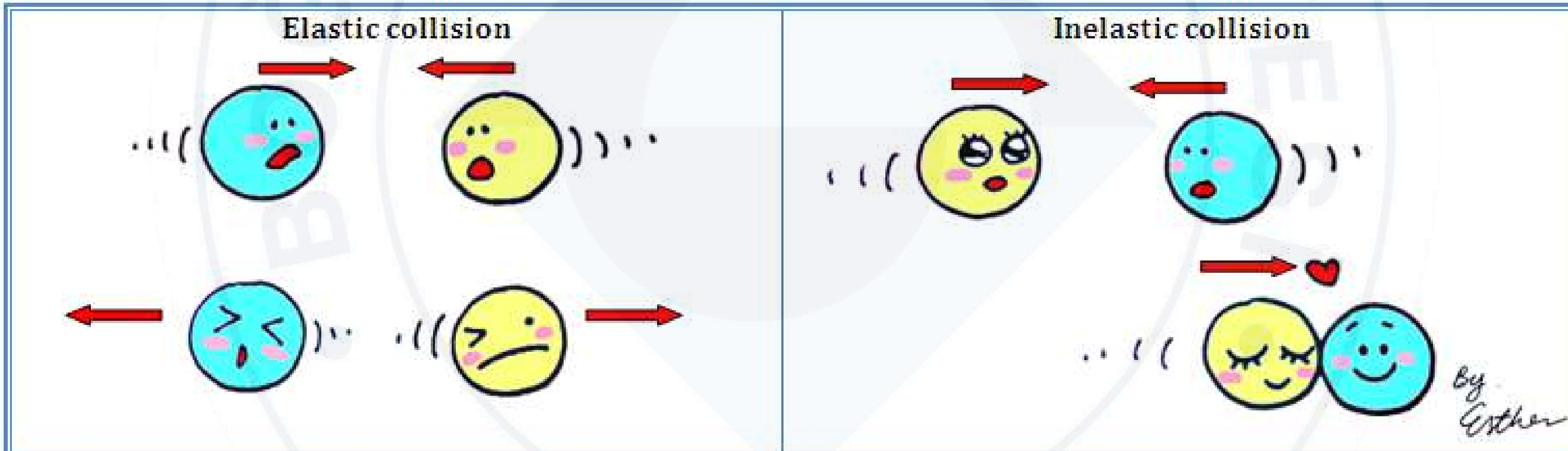
$$p_1 = m_1 \cdot v_1 \ , \ p_2 = 0$$

$$\text{since } v_2 = 0$$

After the collision

$$p_1 = 0 \ , \ p_2 = m_2 \cdot v_2$$

There are two kinds of collision: elastic and inelastic. The kinetic energy is conserved in an elastic collision, but not in an inelastic one. The conservation of momentum becomes especially useful in this case, allowing us to analyze the system despite the loss in energy.

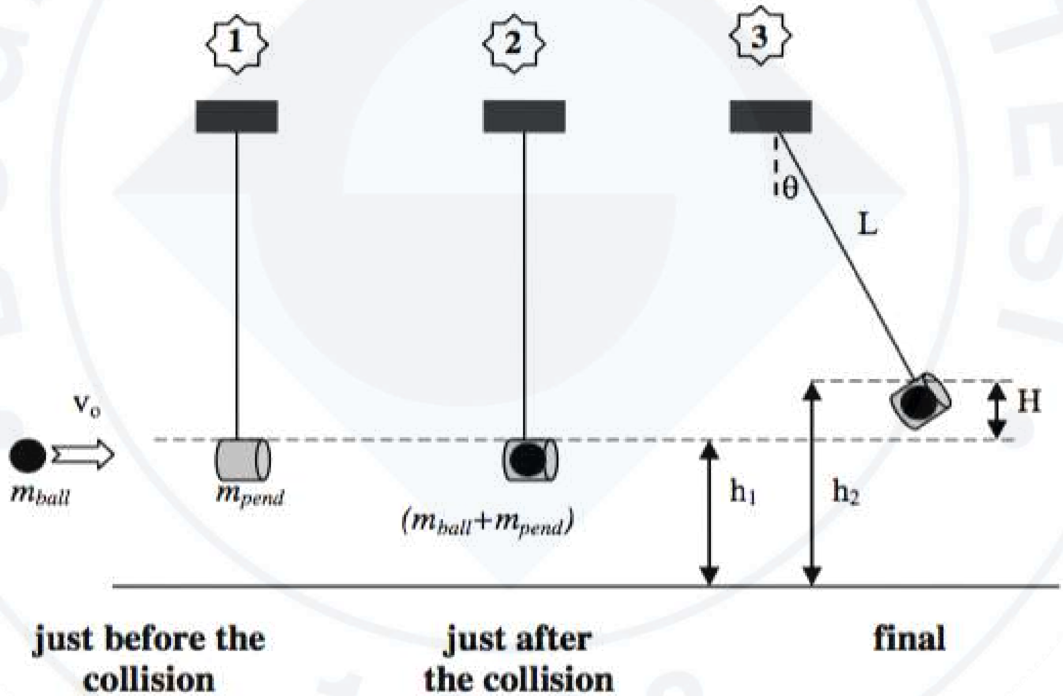


Objects that collide move **separately** after collision.	Objects that collide move **together** after collision.
Total momentum and **total energy** of the system are **conserved.**	
Kinetic energy is **conserved.**	**Kinetic energy** is NOT **conserved.**

CONSERVATION OF MOMENTUM

When the steel ball is shot towards the pendulum attachment of the apparatus, it will hit and stay inside the pendulum attachment.

v_0 is the speed just before the ball sticks to the pendulum.



CONSERVATION OF MOMENTUM

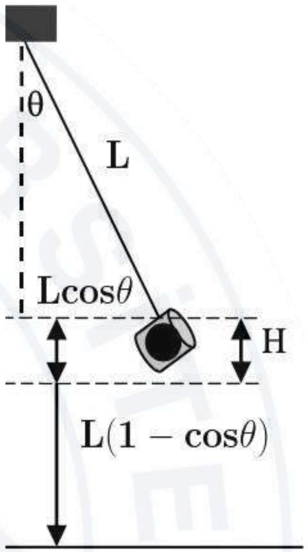
This is an example of a completely inelastic collision. We can express the conservation of momentum during the collision as:

$$m_{ball}v_o = (m_{ball} + m_{pend})v_{final}$$

Since the pendulum attachment is free to swing up, it will do so until all its kinetic energy turns into the potential energy:

$$\frac{1}{2}(m_{ball} + m_{pend})v^2{}_{final} = (m_{ball} + m_{pend})gH$$

The pendulum attachment pushes a pointer as it swings up until it reaches the maximum angle. Using this maximum angle information and the length of the pendulum attachment, we can determine H:



$$H = L(1 - \cos\theta)$$

Then using this value and working backwards from the equations above, we can determine the initial velocity of the ball:

$$v_0 = \frac{m_{ball} + m_{pend}}{m_{ball}} \sqrt{2gH} = \frac{m_{ball} + m_{pend}}{m_{ball}} \sqrt{2gL(1 - \cos\theta)}$$

What to measure :

Mass of the ball, m_{ball}

Mass of the pendulum, m_{pend}

Length of the pendulum, L

Maximum angle, θ

What to calculate :

Average maximum angle, θ_{ave}

Maximum height of the pendulum, H

Average maximum height, H_{ave}

Experimental findings :

Kinetic energy,

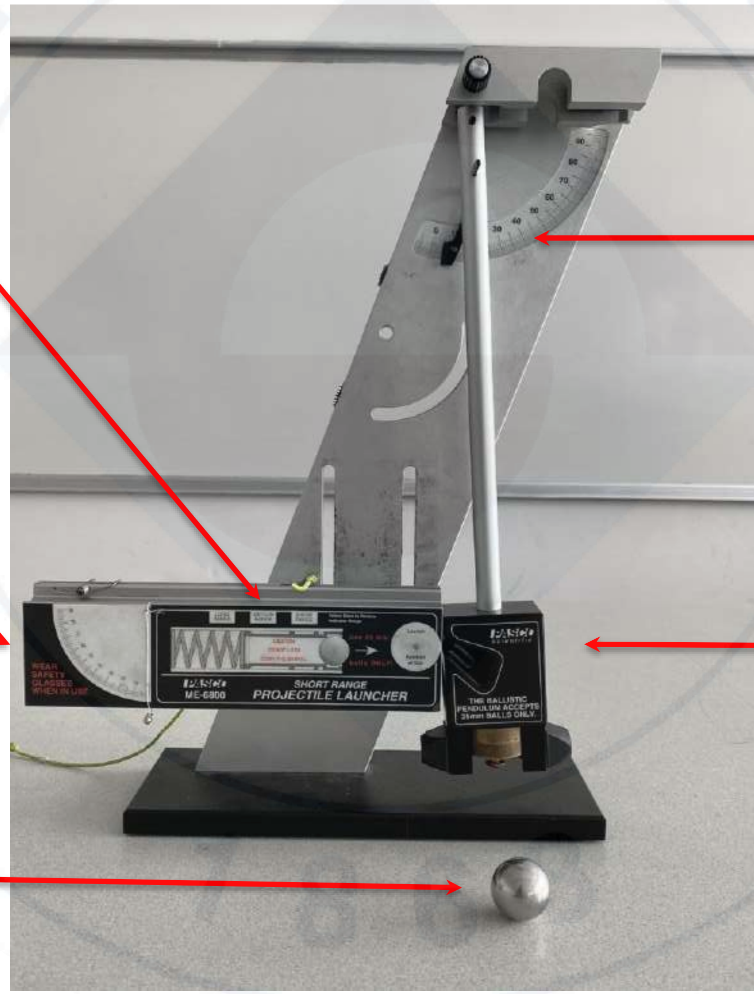
Potential energy,

Initial velocity of the ball. v_0

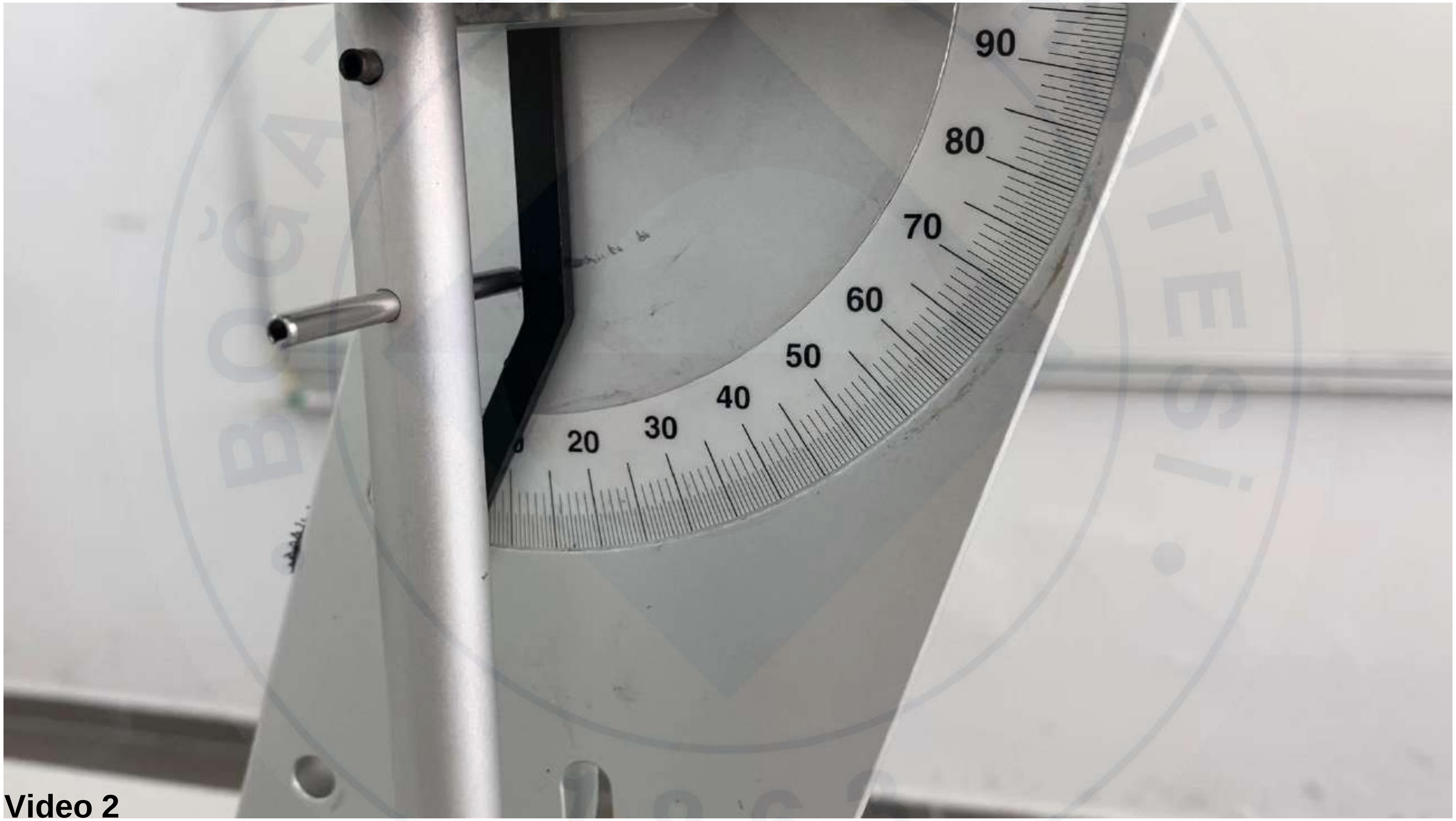
APPARATUS

PhysLabs

The ballistic pendulum setup has two parts: a spring gun to fire the ball at different compressions of the spring inside and a pendulum with a hole to hold the ball.

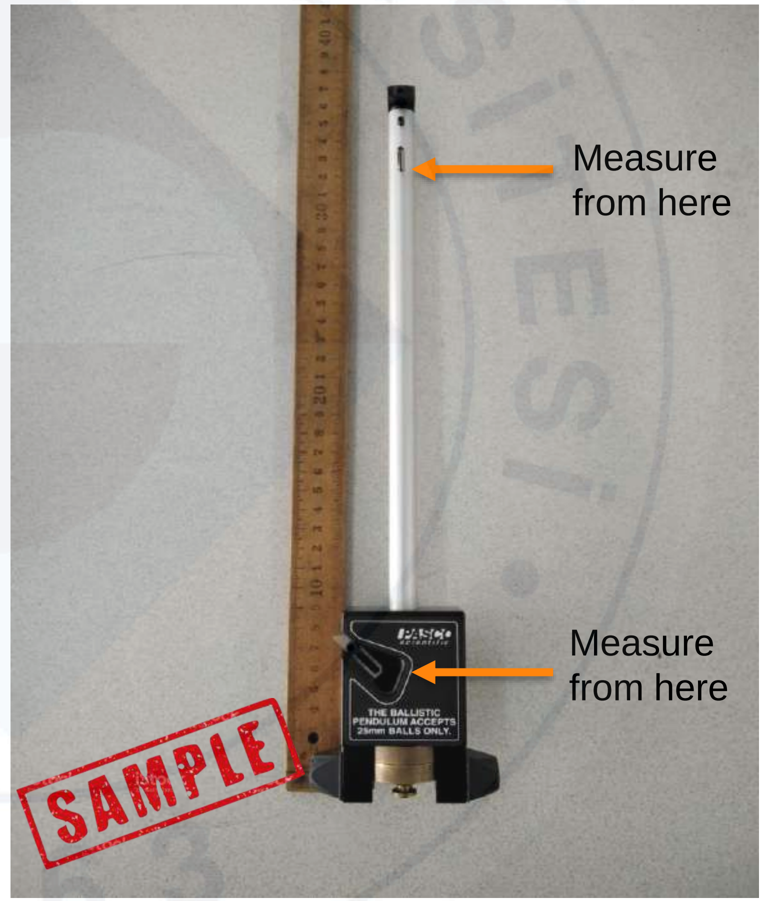


Pendulum pointer and three ranges of spring gun:



Video 2

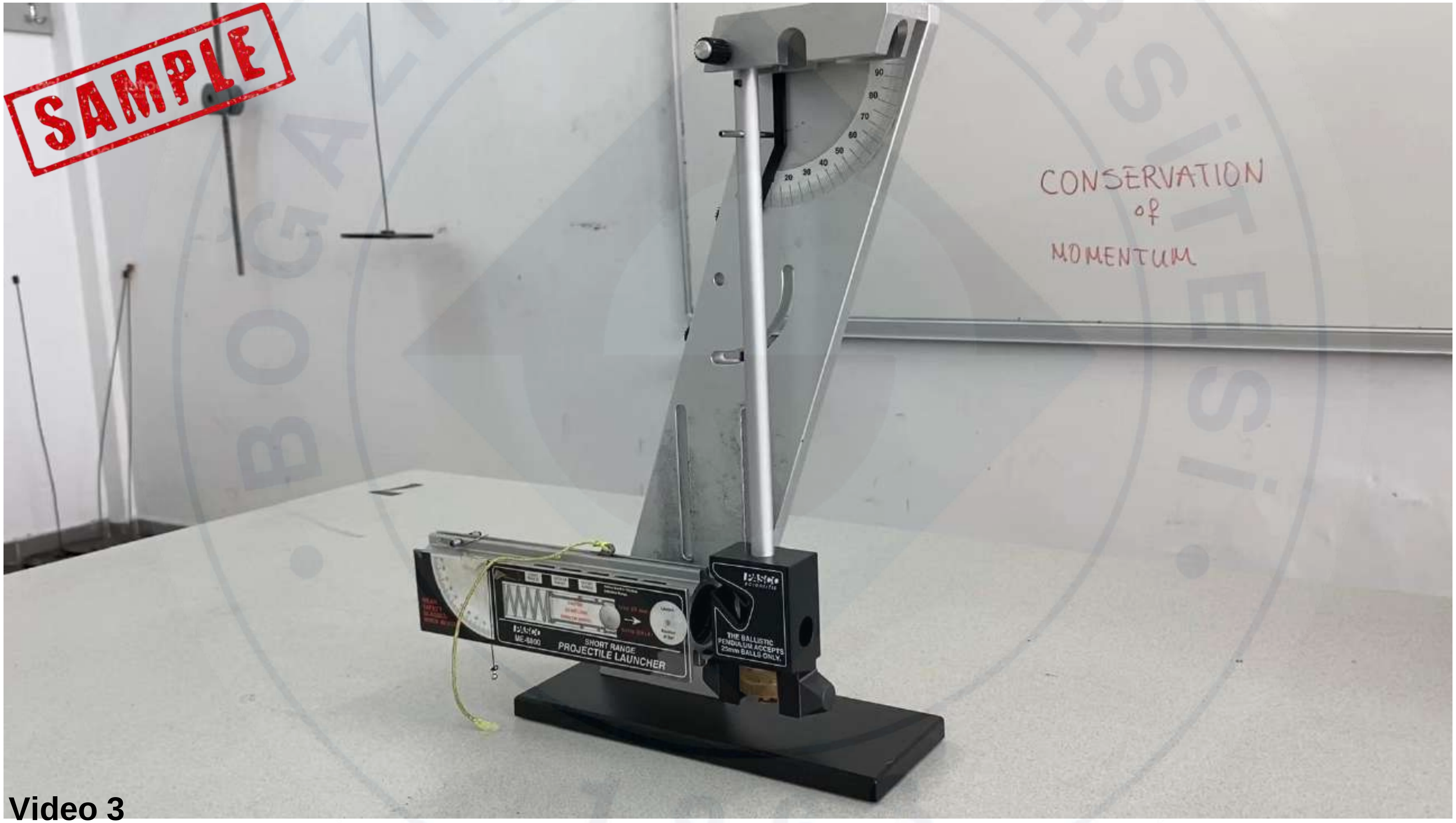
Mass of the ball and the length of the pendulum:



EXPERIMENT

SHORT RANGE:

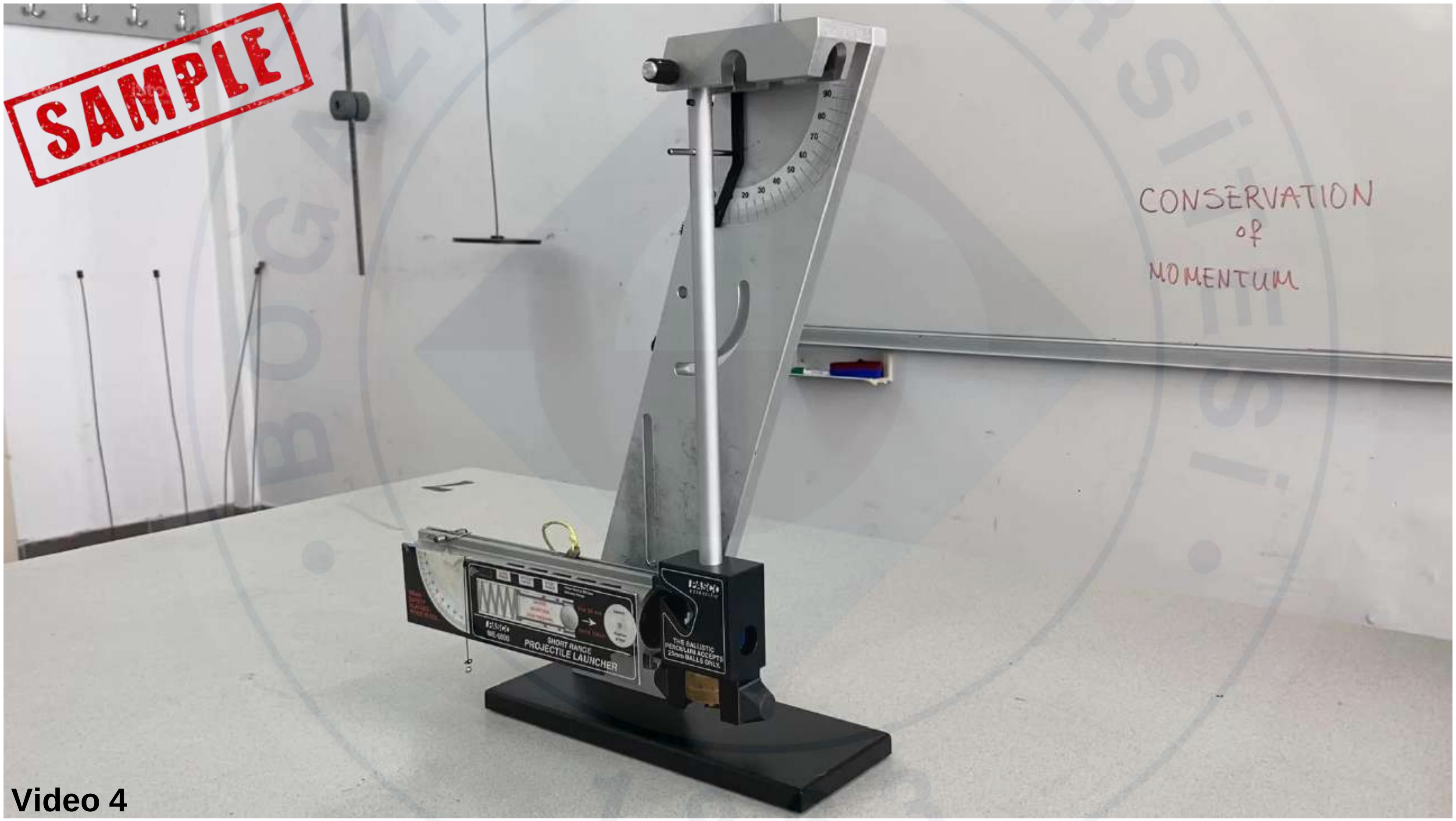
The ball is shot three times at short range and the angle value is read from the indicator.



Video 3

MEDIUM RANGE:

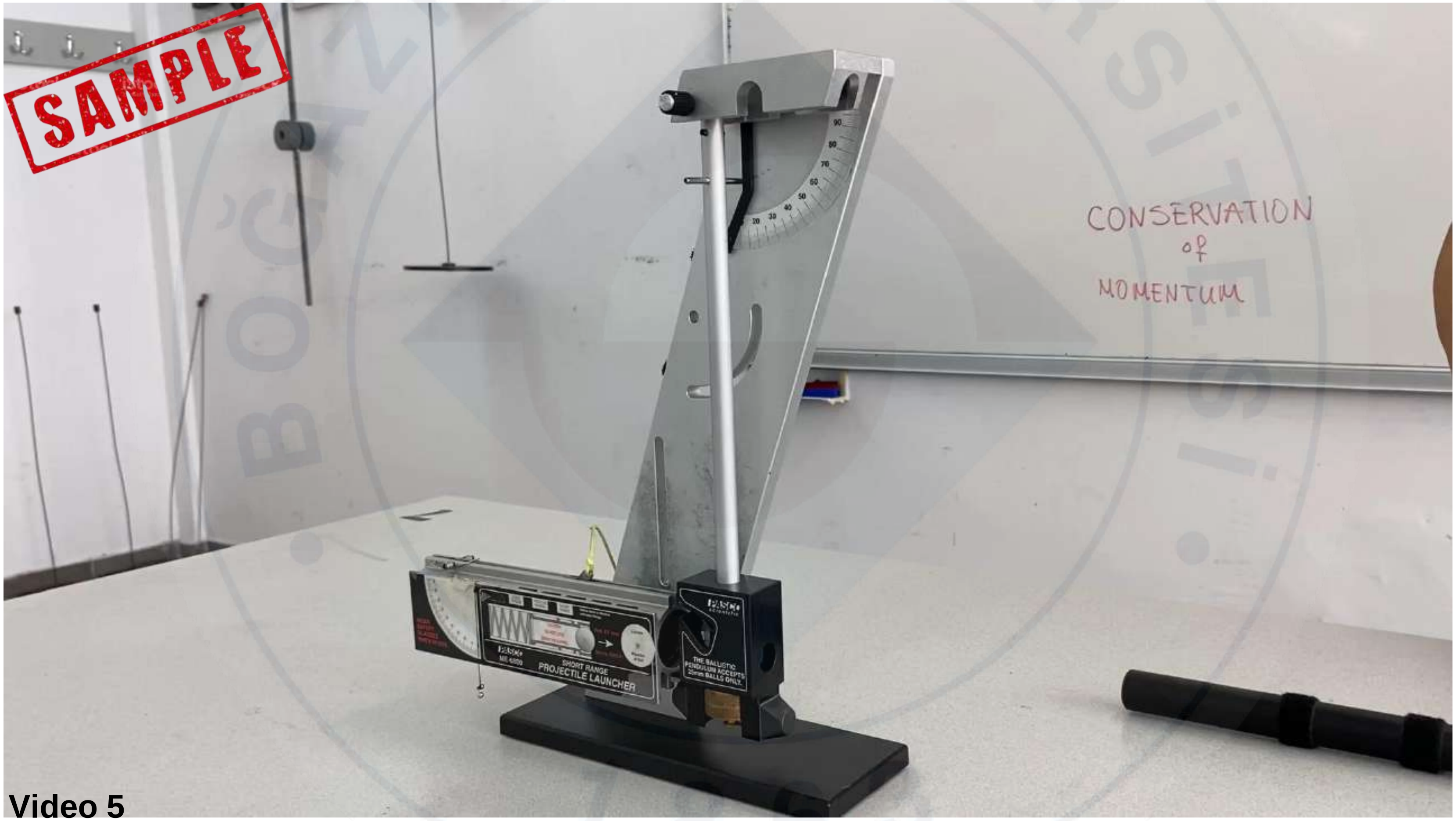
The ball is shot three times at medium range and the angle value is read from the indicator.



Video 4

LONG RANGE:

The ball is shot three times at long range and the angle value is read from the indicator.



Video 5