Problem № 5
«Collision»

Team «12FM»

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The task

A highly elastic Super Ball collides with a rigid surface. How can one determine the collision time? Propose various techniques and compare the experimental results.

Hypothesis

If the Super Ball collapses elastically with the surface, the time of its collision with the surface can be measured.

Aim of the study

Determine the collision time of the Super Ball with a solid surface.

Objectives

1. Study the literature;
2. Study the process of the ball collision with a solid surface;
3. Determine the factors which influence the collision time of the ball with a solid surface;
4. Determine the collision time of a ball with a solid surface;
5. Make a conclusion.

Theory

- <u>Collision</u> - an event in which two or more bodies exert forces on each other for a relatively short time.

- <u>Elasticity</u> — property of solids to return to the original form under elastic deformation.

- <u>Elastic deformation</u> — deformation that disappears after the cessation of actions on the body of external forces. During this deformation an object returns to its original size and shape.

Theory

Let us assume that the collision of a ball on a solid surface consists of two stages: before the bodies collision and after their collision.

1. At the first stage the ball collides with the surface. Part of the kinetic energy of the ball becomes the potential energy of deformation, and the other part is spent to heat the ball, and the deformation takes place until the ball completely loses its speed.

2. At the second stage, the ball returns to its original size and shape due to its elasticity. Due to the heating of the ball, the initial kinetic energy is not completely restored, so, after hitting the surface, the ball acquires a velocity that is moderately smaller than the initial velocity of the ball.
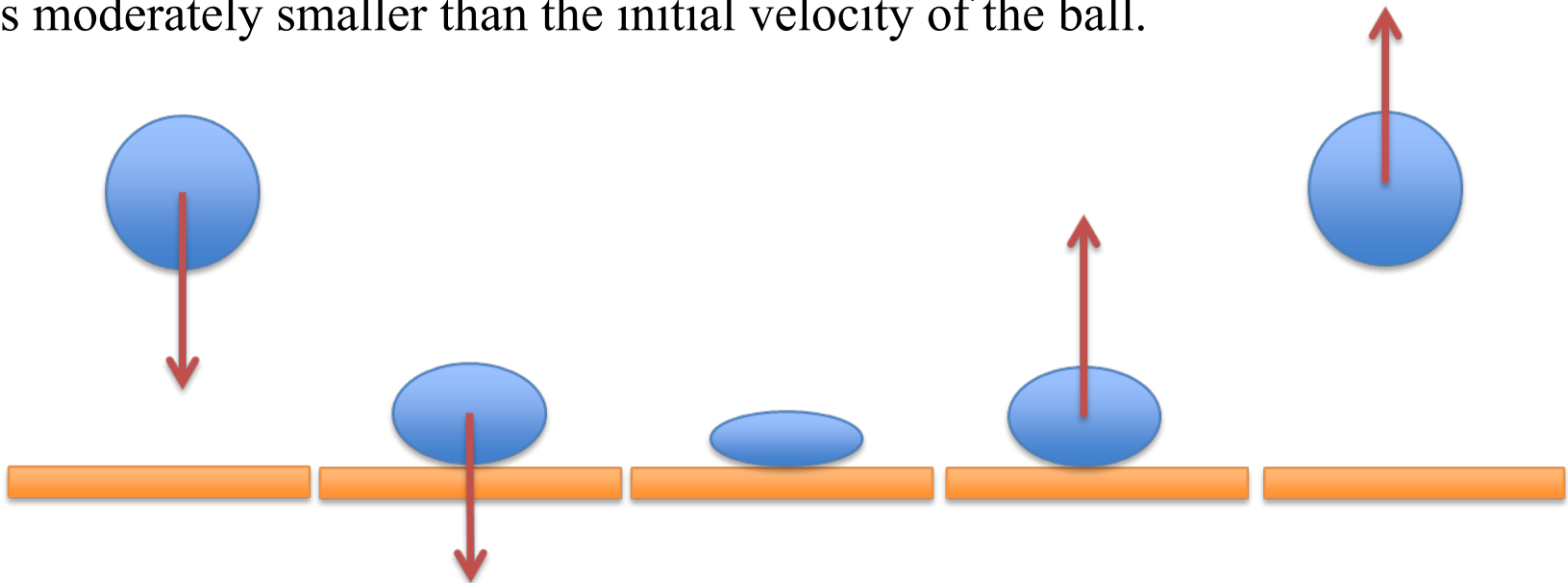
Experimental part

Purpose: to measure the collision time with the greatest accuracy.
Equipment: a ball; a ruler; 2 plates, power supply; electric lamp; clock.
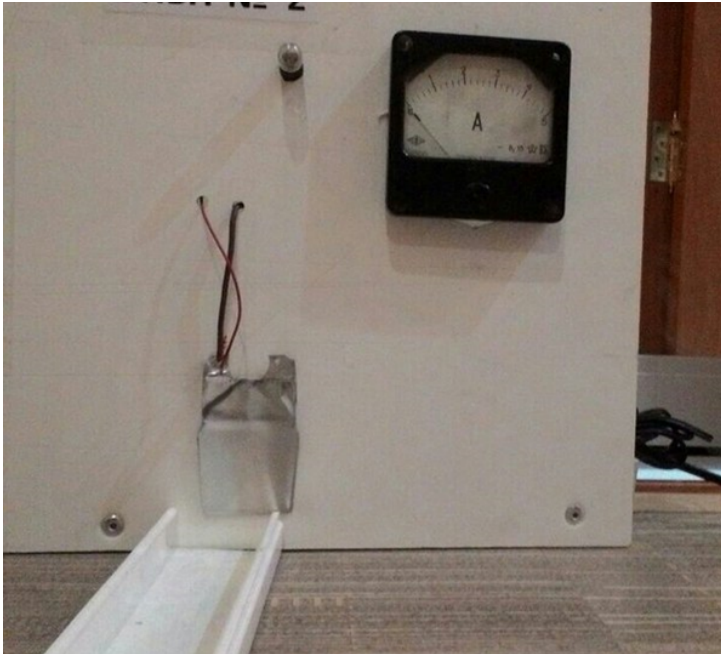
Electronic circuit consisting of two plates, a power source and an electric lamp.

We fasten the plates on the elastic wall so that in the normal state the plates are open, and at the moment of collision the plates are closed.

When the ball hits the plate, a light comes on.

The collision time is 0.08 s.

Experimental part

Purpose: to measure the collision time with the greatest accuracy.
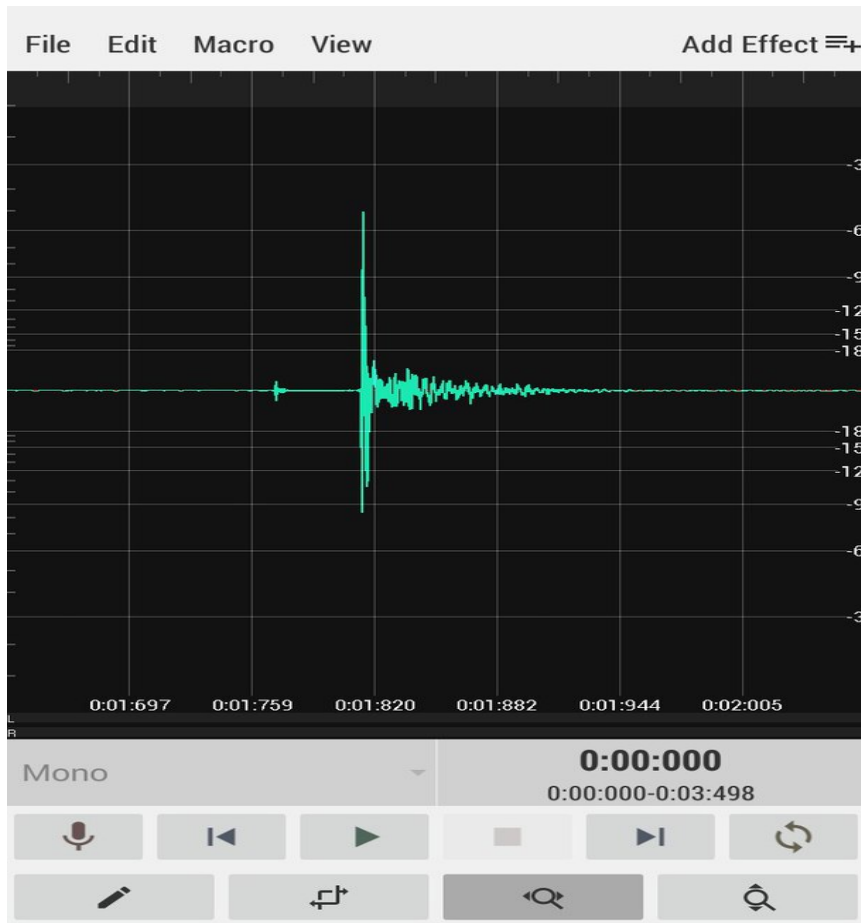**Equipment**: program Movavi; a ball; a camera; a ruler.

The shooting speed is 120 frames per second.
The collision time is 0.06 s.

Experimental part

Purpose: to measure the collision time with the greatest accuracy.
Equipment: program WavStudio; a ball; a ruler.

Then, using the WavStudio program, we measured the time of the sound produced when the ball hits the surface, which in turn is equivalent to the collision time.
The collision time is 0.046 s.

Experiment 1

Purpose: to determine the influence of the ball size on the collision time.
Equipment: program WavStudio, 2 balls of different size.

Conclusion

Ball	Height, cm	Circumference, cm	Radius, cm	Volume cm³	Mass, g	Density, g/cm³	Time, s
Yellow	50	15	2,389	57,084	49,6	0,869	0,141
Pink	50	9	1,433	12,319	10,7	0,868	0,086

$$C = 2\pi R$$

C – Circumference, cm
R – Radius, cm

$$V = \frac{4}{3}\pi R^3$$

V – Volume, cm³
R – Radius, cm

$$\rho = \frac{m}{V}$$

V – Volume, cm³
m – Mass, g
ρ – Density, g/cm³

Conclusion: If density of balls is similar, the smaller the mass of a ball is, the shorter the collision time is. This can be explained by the fact that the area of contact with the surface increases if the ball mass increases.

Experiment 2

Purpose: to determine the influence of the ball elasticity on the collision time.

Equipment: program WavStudio; two similar mass balls with different elasticity.

Conclusion

Ball	Circumference, cm	Radius, cm	Volume, cm³	Mass, g	Density, g/cm³	height, cm	Time, s
Pink	9	1,433	12,319	10,7	0,868	39	0,086
Green	9	1,433	12,319	9,5	0,771	23	0,095

Conclusion: The pink ball is more elastic than the green one. Because when you drop both balls from the same height, the pink ball jumps higher.

The greater the elasticity of the ball, the shorter the collision time is. This can be explained by the fact that the greater the elasticity of the ball, the faster it returns to its original shape.
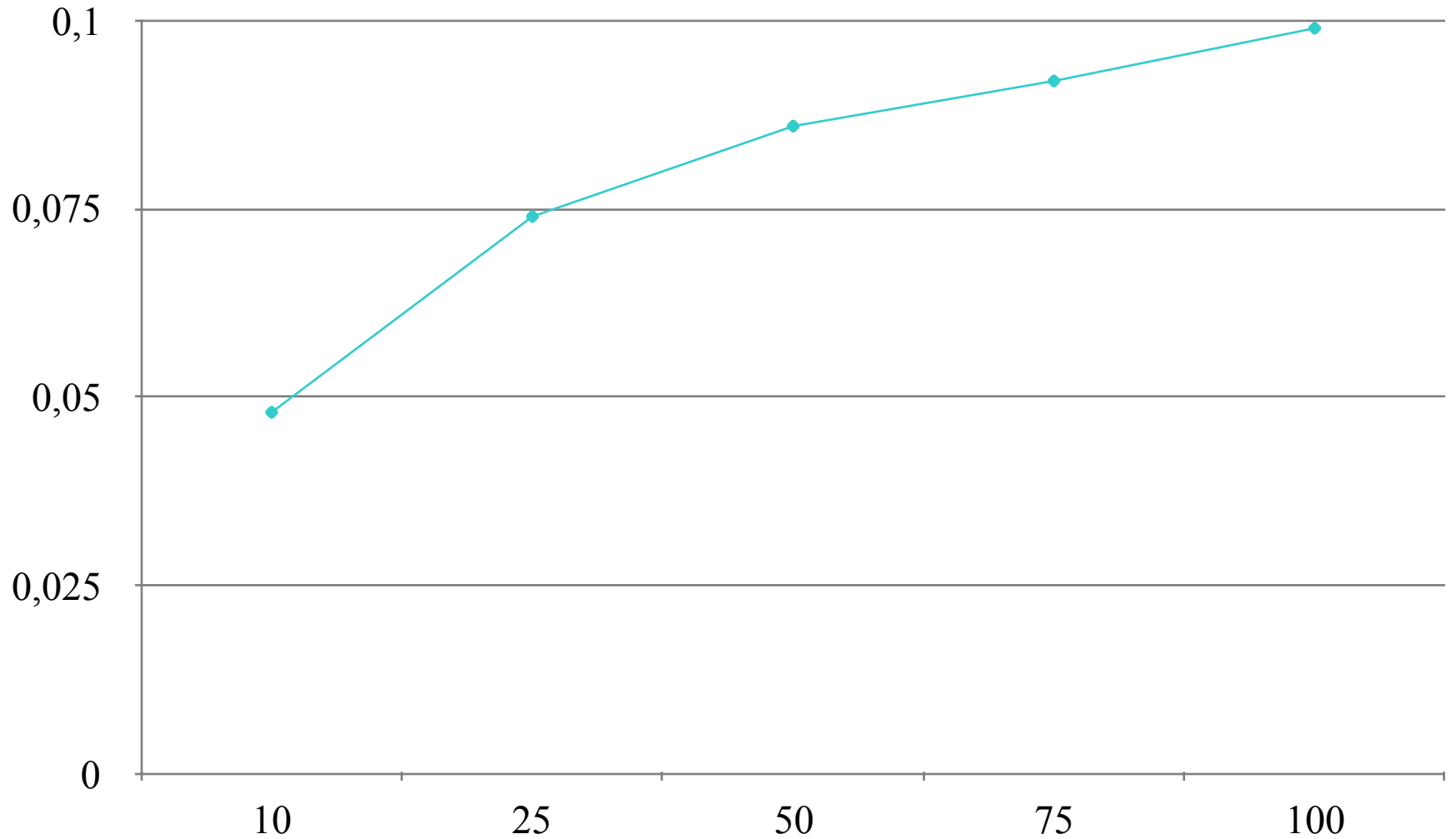
Experiment 3

Purpose: To determine the influence of the height, used to drop the ball, on the collision time.
Equipment: program WavStudio, ball.

Ball	Height, cm	Time, s
Pink	10	0,048
	25	0,074
	50	0,086
	75	0,092
	100	0,099

Experiment 3

Pink ball

Experiment 3

Conclusion: the greater the height, the greater the collision time is. This can be explained by the fact that as the ball falls, the speed of the ball increases at the moment of contact with the surface, therefore the deformation of the ball and the collision time increases.

Conclusion

During the research, the process of collision of a ball with a solid surface has been studied.
Based on the results of the experiments, the following conclusions are:
• The greater the height of the fall of the ball, the greater the collision time is.
• The greater the elasticity of the ball, the shorter the collision time is.
• The smaller the mass of the ball, the shorter the collision time is.

References

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