PRACTICAL 1.3

MEASUREMENT OF THE BULLET SPEED

Objective: studying of the kinematic and dynamic methods of the large-speed measurement.

References: Lab Manual, Penn State University

Equipment: air gun, bullets, ruler, paper, electric rotor, ballistic pendulum.

INTRODUCTION

During the measurement, two different methods of the large-speed evaluation are used.

Kinematic method is based on the measurement of *time* which is needed to the object (the bullet) to cover a known distance *d*. Here, the distance is determined by the position of a pair of paper discs, and the time is estimated by the angular displacement α of the "shell hole" in the 2nd paper disc in relation to that in the 1st paper disc, and the known rotation speed of the discs. Speed of the bullet is (prove the formula!): $v=\omega d/\alpha$ with ω being the angular (rotation) speed.

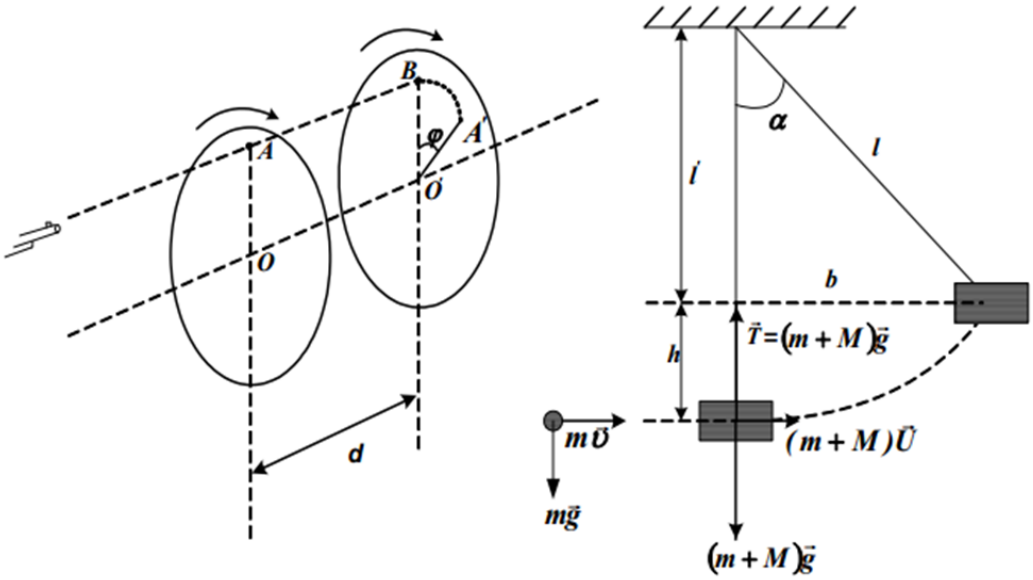

Fig. 3. (left) kinematic method. (right) dynamic (ballistic) method.

Dynamic method (ballistic pendulum method) is based on the angular deviation of the pendulum resulting from the bullet hitting the pendulum. Assuming that linear deviation of the pendulum a is much smaller than the suspension length l, the speed of the pendulum (u) *at* the moment of the collision is (prove the formula with use of the energy conservation law!)

$$u = a\sqrt{\frac{g}{l}}, \tag{1}$$

With use of the momentum conservation law and an assumption that the pendulum mass M is much greater than the bullet mass m, the bullet speed is (prove the formula!):

$$v = \frac{Mu}{m} = \frac{Ma}{m}\sqrt{\frac{g}{l}}, \tag{2}$$

DESCRIPTION OF THE EXPERIMENTAL SETUP

The two paper discs are fixed at different sides of the rotation sheave. The air gun is pointed to the ballistic pendulum filled with the plasticine. An experimenter should read out the linear displacement of the pendulum. After the shot, angular displacement is measured by a protractor.

MEASUREMENTS AND PROCESSING OF RESULTS

Attention! All the measurements are done with the single air gun shot.

1. Prepare the paper discs. With use of a pencil, mark their “zero” position. Write down all the relevant numbers and characteristics of the setup.

2. Fix the paper discs. Weight the bullet.

3. **Attention**! Load the air gun only in sight of the lab teaching engineer or the teacher!

4. Start the electric rotor. Wait for a few minutes needed for it to warm up.

5. Shot the air gun. Measure the linear displacement of the ballistic pendulum. 6. Stop the rotor. Measure the angular displacement α between the two shell holes.

7. Calculate the bullet speed by the two methods. Form a table with the measurement results including data for m, α, a, ω, v.

8. Estimate errors provided by the two methods.

QUESTIONS AND EXERCISES

1. Explain the difference (if any) of the bullet speed measured by the kinematic and dynamic methods?

2. Calculate a change of the internal energy in the system "ballistic pendulum - bullet" undergoing an inelastic collision?

3. How the measurement results would be affected if the bullet would hint the pendulum under an angle?

4. What is the tension force before the shot and right after the shot?

5. Prove formulas (1) and (2).