PRACTICAL 1.2

STUDY OF THE LINEAR MOTION WITH USE OF THE ATWOOD MACHINE

Objective: experimental study of the linear motion, measurement of the momentum velocity and acceleration.

References: Mechanics (Berkeley Physics Course, Vol. 1).

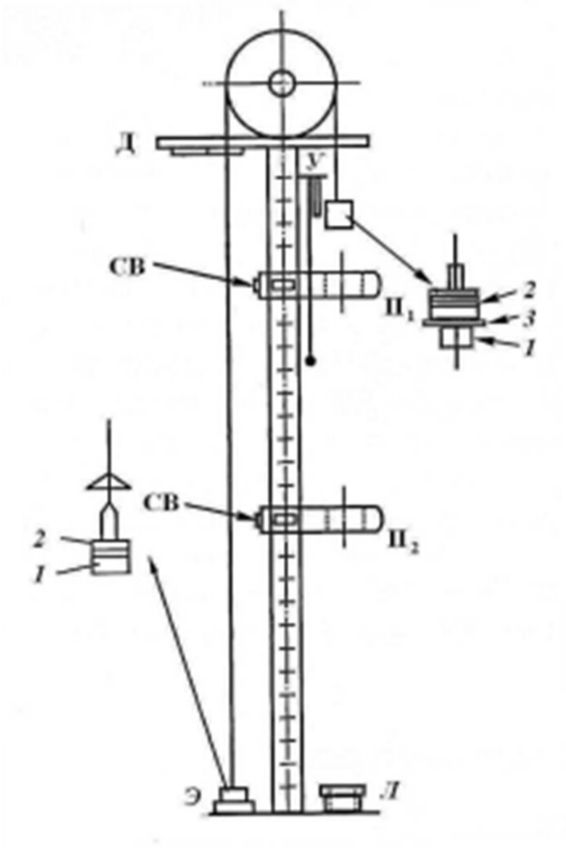
Equipment: Atwood's machine, set of loads.

INTRODUCTION

In the practical, kinematic characteristics are being measured, and the correctness of the second law of Newton is being checked out. For the measurement, the Atwood machine is used, which was invented by George Atwood in 1784. For the kinematic characteristics calculation, trajectory and time are measured.

DESCRIPTION OF THE EXPERIMENTAL SETUP

An ideal Atwood Machine consists of two objects of mass m_1 and m_2, connected by an inextensible massless string over an ideal massless pulley. The movement of the objects occurs along a vertical ruler provided with centimeter divisions (Fig.2). There are two movable platforms $П_1$ и $П_2$. which are fixed by “centering bolts” marked as “CB”. The platforms are equipped with photo-sensors allowing for exact registration of time moments t_1 and t_2 at which the load pass the platforms $П_1$ and $П_2$, respectively. An electric magnet is used to block one of the loads at the bottom position. A damper is used to kill out any possible oscillations of the loads. As the both loads have same mass, an *extra*-load is needed to cause the system movement. As the extra-load is placed on top of a load, the system undergoes a uniformly accelerated motion. At the moment the load passes the platform $П_1$ the extra-load is released, and the motion becomes uniform.



MEASUREMENTS AND PROCESSING OF RESULTS

Task 1. **Measurement of acceleration and instantaneous velocity during the uniformly accelerated motion.**

During the measurement, lengths x_1, x_2 and time intervals t_1, t_2 are measured. Using extra-loads of 5, 10, 15, 20 g measure time intervals of accelerated and uniform motion. For every extra-load, use two different lengths x_1. (e.g., 0.5 and 1.0 m). **Catch** the loads in the end of the motion (to prevent the set-up damage).

Calculate the instantaneous velocity v_{m_1} at the end of the accelerated motion and uniform velocity v_2. Calculate averaged acceleration a for each set of data. Perform the error analysis. Organize data (x_1, x_2, t_1, t_2, v_{m_1}, a, v_2) in a table :

Extra-load mass, g	Accelerated motion						Uniform motion			
	x_1	t_1	a	a_{avg}	v_{m_1}	v_{avg}	x_2	t_2	v_2	v_{2_avg}
	$x_{1\ 1}$	$t_{1\ 1}$					$x_{2\ 1}$	$t_{2\ 1}$		
	$x_{1\ 1}$	$t_{1\ 2}$					$x_{2\ 1}$	$t_{2\ 2}$		
	$x_{1\ 1}$	$t_{1\ 3}$					$x_{2\ 1}$	$t_{2\ 3}$		
	$x_{1\ 2}$	$t_{1\ 4}$					$x_{2\ 1}$	$t_{2\ 1}$		
	$x_{1\ 2}$	$t_{1\ 5}$					$x_{2\ 1}$	$t_{2\ 2}$		
	$x_{1\ 2}$	$t_{1\ 6}$					$x_{2\ 1}$	$t_{2\ 3}$		

Task 2. **Study of the acceleration dependence on the accelerating force with the constant mass of the system.**

Place the extra-loads on both loads. Perform measurements replacing the extra-loads from side-to-side at each measurement iteration. Write down time intervals of the accelerated motion. Set length x to about 1 m. Place the 2nd platform slightly below than the 1st one. Calculate the acceleration a and plot dependence of the acceleration a on the relative mass imbalance $\Delta m/M$, where Δm is the difference between the extra-loads placed on top of the 1st and 2nd loads, and M is the total system mass. Find out a theoretical dependence in a form of $a = f(\Delta m/M)$ and plot it on the same graph. Organize data (x_1, t_1,, Δm, a, M) in a table. Perform the error analysis.

QUESTIONS AND EXERCISES

1. Prove the formula for v_{m_1}.
2. Write down the motion equation for all the objects in the system.
3. Calculate the tension force.
4. With what force an extra-load affects the load?
5. Plot the coordinate, velocity, and acceleration dependences on the time.
6. Estimate the measurement errors.
7. Consider the case with a massive pulley. Write down the motion equations.