A01-316E-Y01

Ballistic Pendulum

Purpose

Use the ballistic pendulum to observe the collision phenomenon of two objects and record their results. The experiment can examine the conservation of momentum and kinetic energy. In normal situation, a collision can be classified into two types, perfectly elastic collision and perfectly inelastic collision. In this experiment, we will discuss the situation of perfectly inelastic collision.

Theory

From the conservation of momentum, we know that

$$\Delta\vec{p} = m\Delta\vec{v} = \vec{F}\Delta t$$

When two objects oscillate, the motion system conserves the momentum. Based on the law of conservation of energy, the system's energy can be classified into two types:

1. The energy is completely transferred to kinetic energy which is conservation of kinetic energy.

2. If the energy cannot be completely transferred to kinetic energy due to fraction, resistance or deformation, it loses its kinetic energy or is transferred to other form of energy such as heat but the total energy in the system is conserved. The kinetic energy is not conserved in the collision.

Suppose masses of two objects are m_1 and m_2, original velocities of objects are v_1 and v_2, and final velocities of objects are u_1 and u_2. Based on the law of conservation of momentum, the formula can be expressed as:

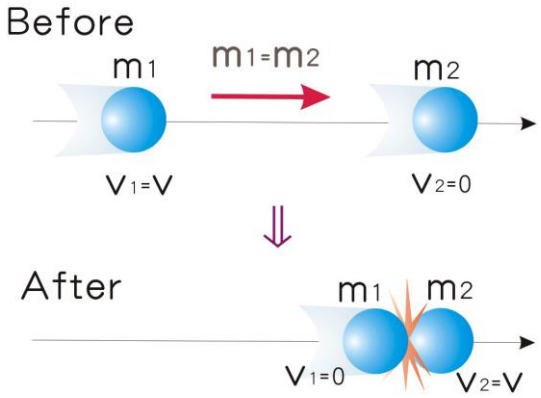
$$m_1\vec{v}_1 + m_2\vec{v}_2 = m_1\vec{u}_1 + m_2\vec{u}_2$$

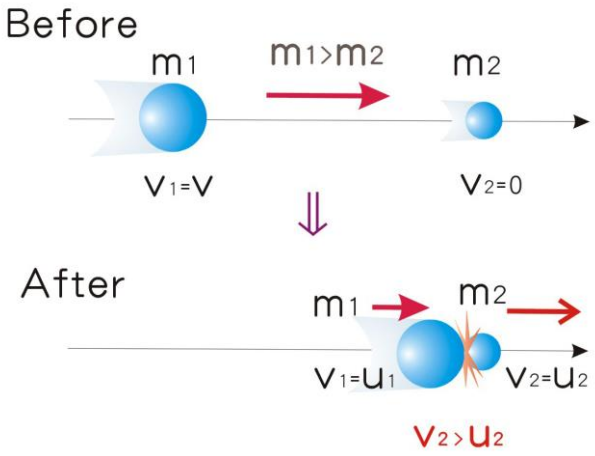
The velocity difference before the collision of two objects is $v_1 - v_2$. The velocity difference after collision is $u_1 - u_2$. The ratio of the velocity differences is the coefficient of restitution e.

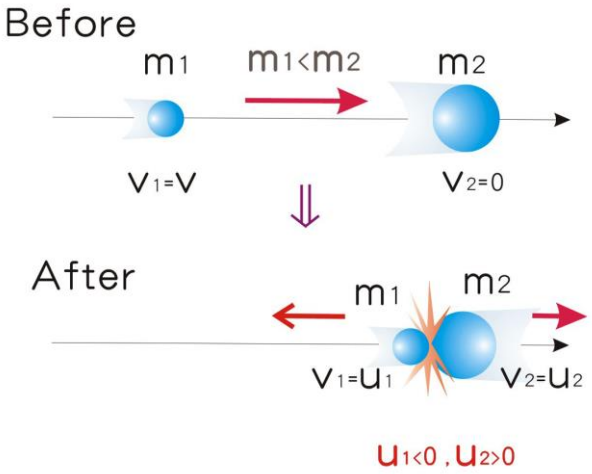
$$e = \frac{u_2 - u_1}{v_1 - v_2}$$

According to above description, if we ignore the ground fraction and the air resistance in a motion system, the collision can be classified into

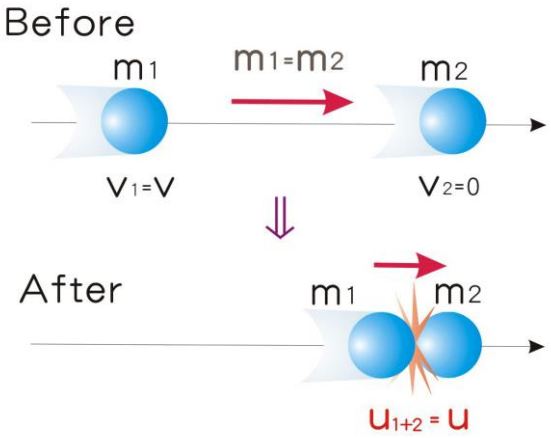
1. Perfectly elastic collision (e = 1)






Before
m1
m1<m2
m2
v1=v
v2=0
After
m1
m2
v1=u1
v2=u2
u1<0 , u2>0

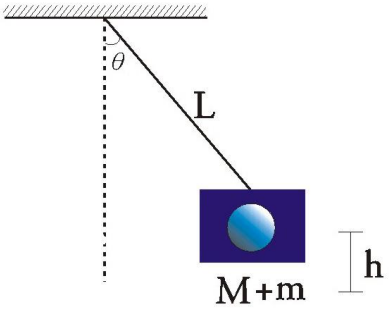
2. Perfectly inelastic collision ($e = 0$)



3. Non-completely elastic collision ($0 < e < 1$)

The ballistic pendulum in this experiment is perfectly inelastic collision.

Ballistic Pendulum



From the law of conservation of energy and conservation of momentum, we know that

$$P_i = P_f \quad \text{and} \quad mv = (M + m)V$$

$$(K.E)_{bottom} = (P.E)_{top}$$

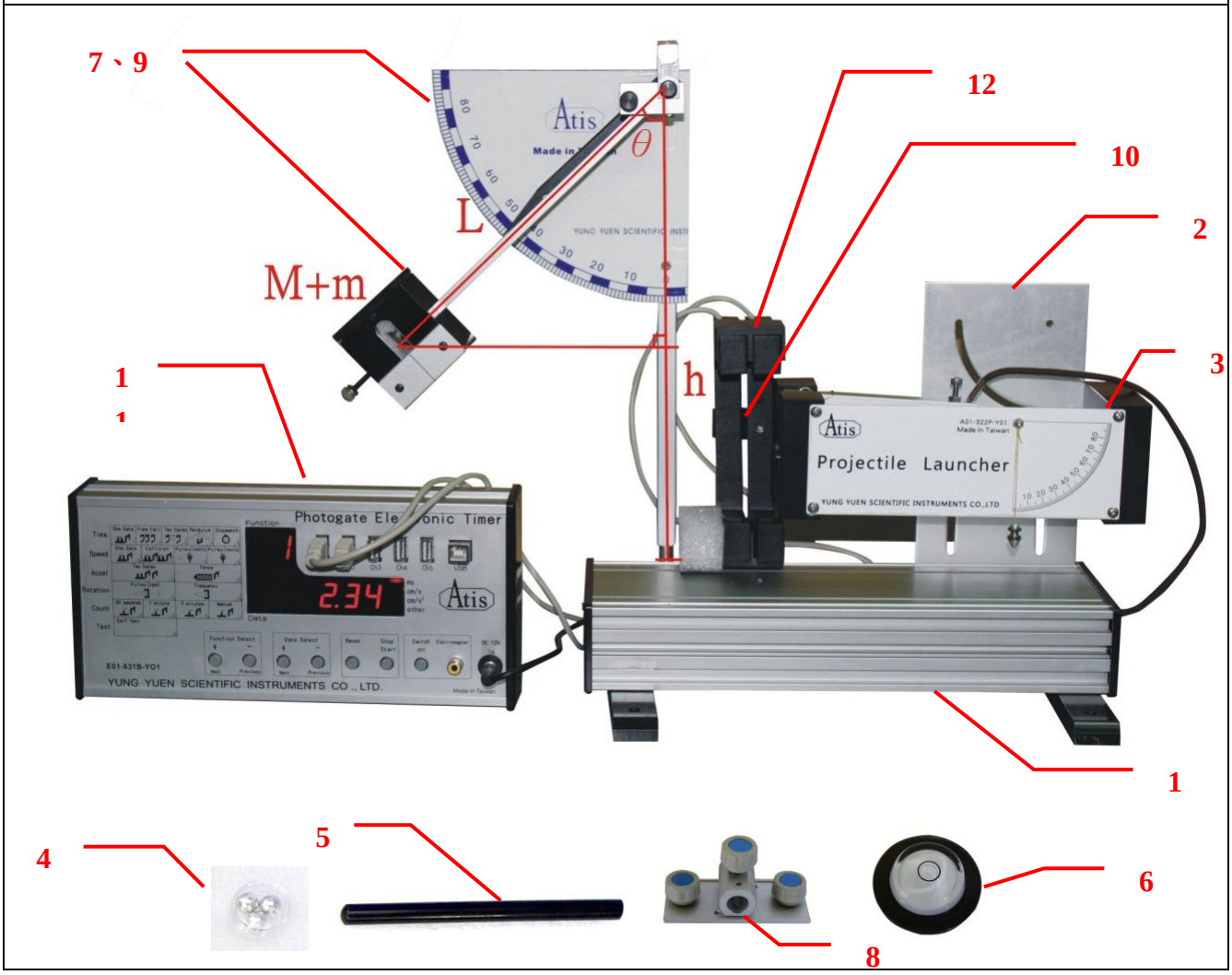
$$\frac{1}{2}(M+m)V^2 = (M+m)gh$$

$$h = L \times (1 - \cos\theta)$$

Total energy may or may not be lost during the experiment process. In this experiment, we assume the lost of energy is small and can be ignored.

Instruments

Instrument List					
No.	**Accessory**	**Qty**	**No.**	**Accessory**	**Qty**
1.	Multi-function aluminum base (including slide implement *1)	1	**2.**	Launcher holder (with large knob* 4)	**1**
3.	Projectile launcher (including slide implement*1)	1	**4.**	Set of steel balls (D16mm×3)	**1**
5.	Loading rod	1	**6.**	Level	**1**
7.	Accessory of ballistic pendulum (including ballistic pendulum, angle disk, indicator, fixed slotting and board)	1	**8.**	Movable connector base	1
9.	Weight 50g	2	**10.**	Set of photogate fixer (with clips)	1
11.	Photogate electronic timer (with power supply 12 VDC) Note: Additional purchase		**12.**	Photogate (with metal fixed knob) Note: Additional purchase	

Instrument picture


Procedure

1. Use the level to check if the table is in horizontal status. The experimental setup is shown in below figures.

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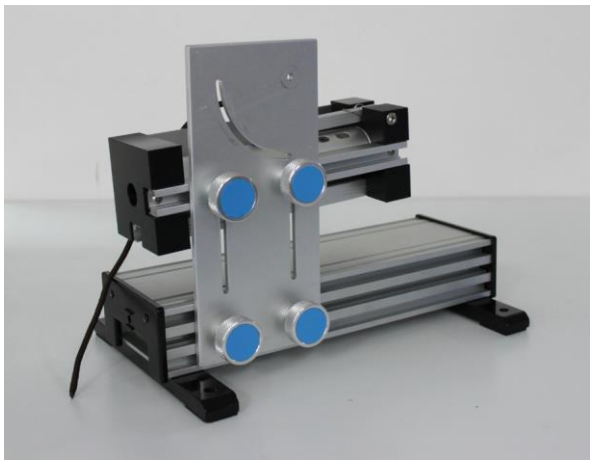
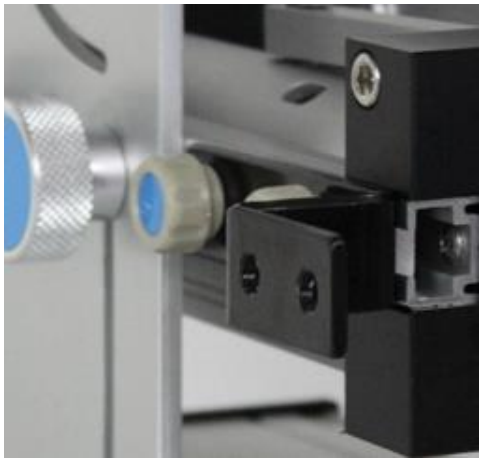
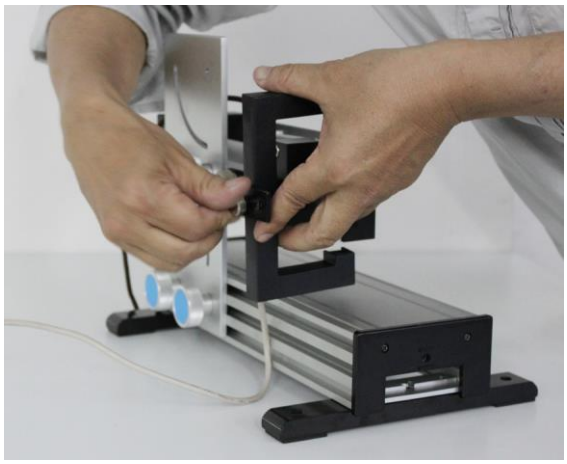
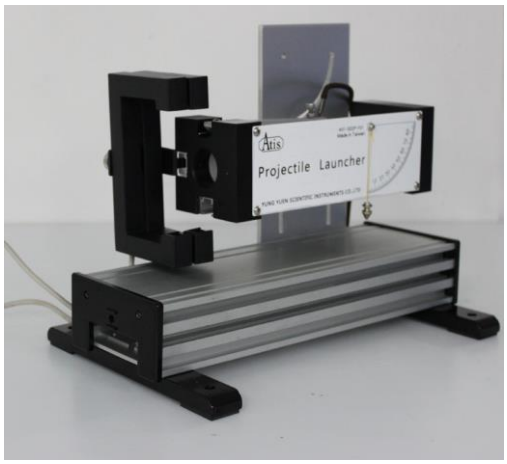
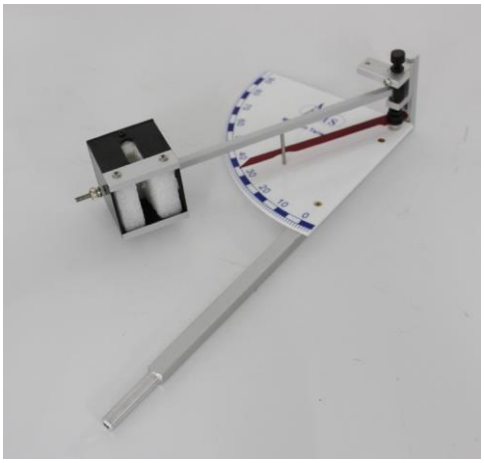
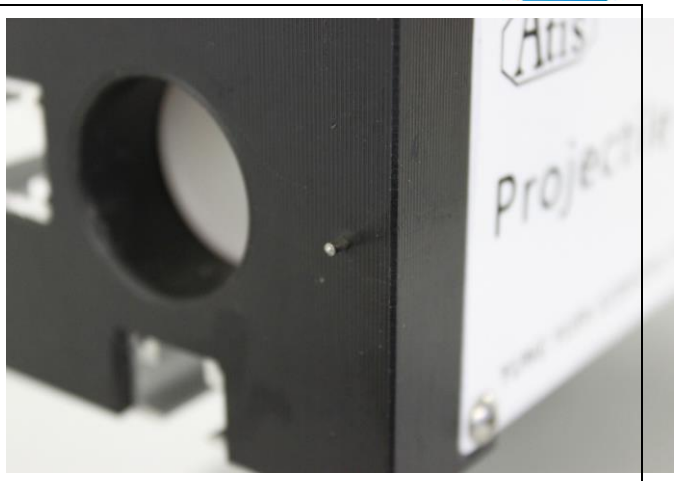
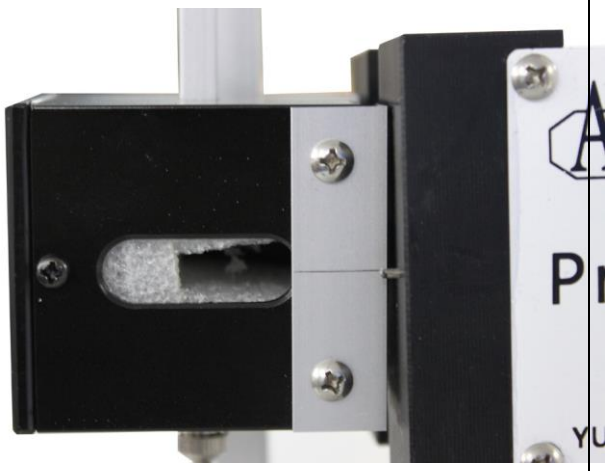
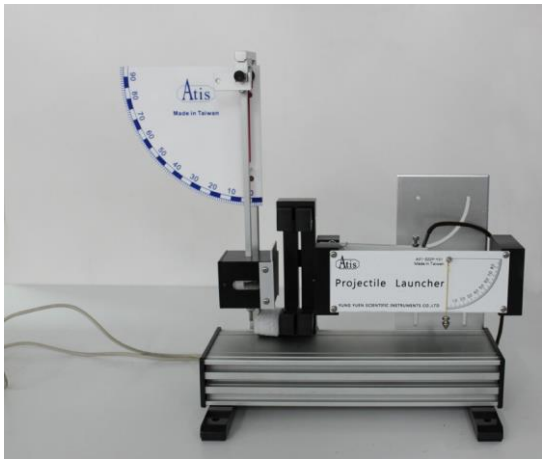
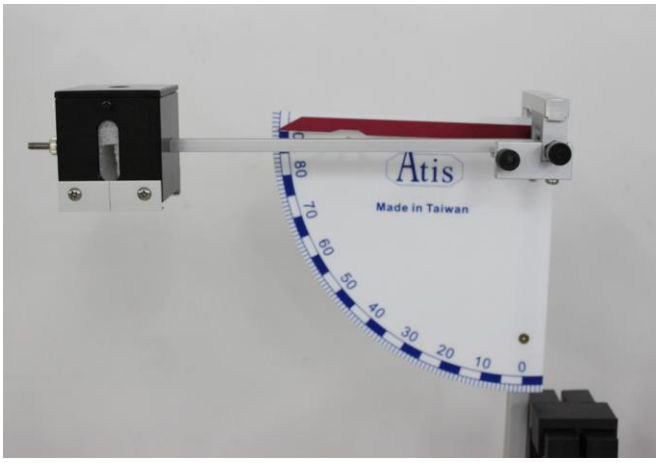
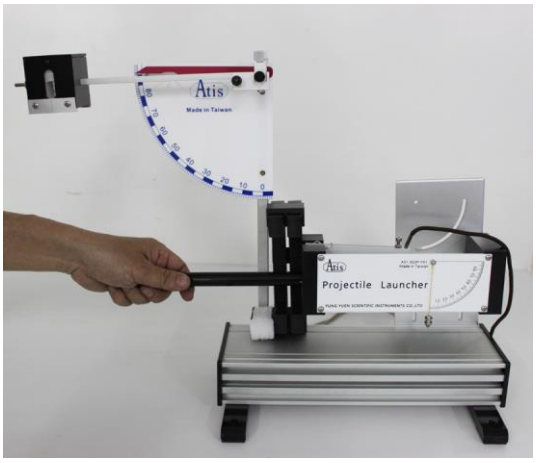
<tr><td>  </td><td>  </td></tr>
<tr><td>1. Use the large knob to fix the launcher on the side of base.</td><td>2. Use the large knob to fix the launcher.</td></tr>
<tr><td> 
</td><td>  </td></tr>
<tr><td>3. Adjust the level to zero.</td><td>4. Install the photogate fixer. ◦</td></tr>
<tr><td>  </td><td> 
</td></tr>
<tr><td>5. Assemble the photogate.</td><td>5. Finish the setup of 2 photogate.</td></tr>
</table>

	
4. The setup of ballistic pendulum.	5. The marked supporting point at the launcher.
	
6. The distance between the pendulum and the launcher is the marked supporting point.	7. Complete setup of the ballistic pendulum.
	
8. Use the slot to fix the ballistic pendulum at higher position.	9. Load steel balls.