Relationship between "Collision Apparatus for Kinetic Energy" and the law of conservation of mechanical energy

NaRiKa Corporation

1. Relationship between "Collision Apparatus for Kinetic Energy" and the law of conservation of mechanical energy

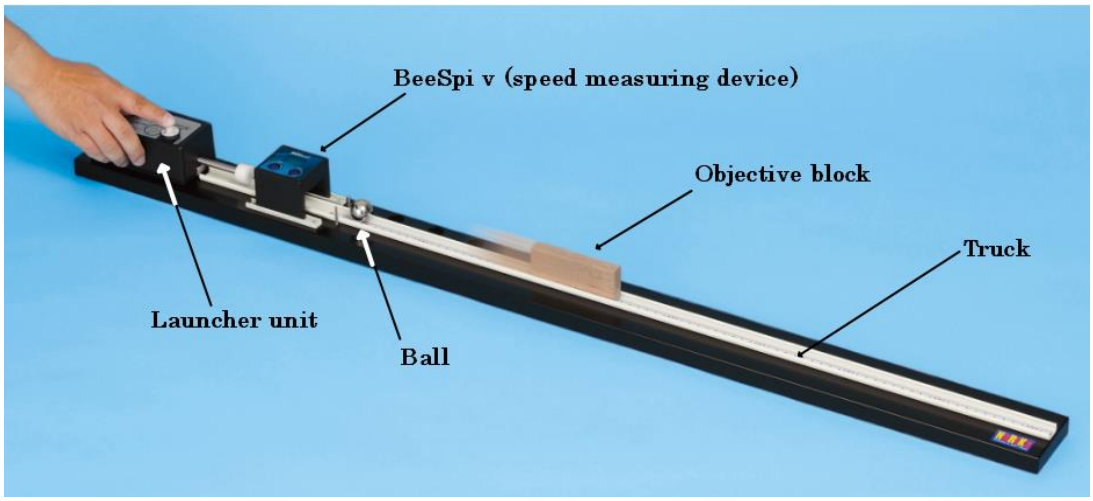
There are various ways to verify the formula of kinetic energy by experiment. In many of these experiments, actual fall distance of pendulum, ball on inclined plane or others are used to verify the formula indirectly without directly measuring velocity of objects. In other words, these experiments are only indirectly verifying the formula of kinetic energy.

$$E = \frac{1}{2}mv^2 \qquad \frac{1}{2}mv^2 = mgh$$

Direct verification of the formula is possible by measuring each of the E, m and v^2. Narika's product, Collision Apparatus for Kinetic Energy (C15-2455-W1), is intended to measure (the relationship between) the velocity of a ball launched with certain force and the distance of the objective block moved after collision with the ball. The main feature of this product is its capability to launch a ball in horizontal direction. This allows students to focus only on the kinetic energy phenomena without confusing it with potential energy phenomena as in experiments with inclined plane or pendulum that inevitably include element of "height" of object.

1. Feature and specification of Collision Apparatus for Kinetic Energy

This apparatus includes a"Horizontal Ball Launcher"and BeeSpi v for measuring velocity of the launched ball. Kinetic energy change depending on the velocity of the ball can be quantitatively obtained by measuring moving distance of wooden block when getting collision of horizontal launched ball on the guide rail.



* Launcher unit has function to adjust initial velocity of the ball. Using a speed measuring device, such as "BeeSpi v" together, initial velocity of the ball can be measured.
* On the main body next to the track there are 3 holes where balls can be placed during the

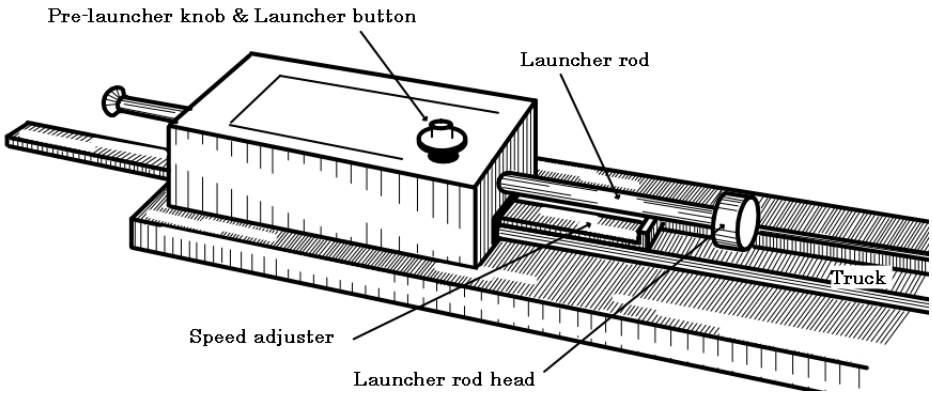
experiment.

* The wooden block moving distance after the collision can be read from the scale at once during the experiment.

Main Body	:	Approx. 1,150 x 80 x 70 mm (launcher unit included)
Launcher unit	:	Continuously and non-continuously knob for control the initial velocity.
Balls	:	Steel ball (diameter 25mm, 67g) x 1, Ceramic ball (diameter 24mm, 19g) x 1, Plastic ball (diameter 25mm, 9.5g) x 1.
Truck	:	Plastic truck (length 1,000mm) with a scale (length: 820mm, 1mm graduation)
Wooden block	:	Objective block (approx. 14 x 100 x 40 mm, approx. 28g) x 1
BeeSpi v	:	A speed measuring device (S77-1321-W0) x 1

2. Collision Apparatus for Kinetic Energy Parts Introduction

1. Description of Launcher unit



*Pre-launcher knob (= PL knob)	:	This is a knob to set the launcher rod at the position of launcher as a part of preparation.
*Launcher button (= L button)	:	Launcher button is for launching a ball. When pushed after setting the launcher rod by “PL knob”, the launcher rod will launch a ball.
*Speed adjuster (= S adjuster)	:	Launch speed can be controlled by the launch adjuster. Launch speed can be adjusted at three steps and as well continuously between the steps.
*Launcher rod head (= LR head)	:	There is a plastic block on top of launcher rod called launcher rod head. It pushes the ball out.
*Launcher rod	:	Launcher rod is like a cue stick.

2. Operating Launcher unit

1. Push and slide “S adjuster” to any position of three levels to set the launcher power (see Fig.1).
2. Turn “PL knob” up clockwise to 180 degrees to upper position (see Fig.1).
3. Move pushing “LR head” to the point of “S adjuster” and set the launcher rod (see Fig.2).
4. Set the ball at the launch position (see Fig.3).
5. Push “L button” for launching the ball while holding the launcher unit down by your hand, so that the apparatus will not move (see Fig.4).

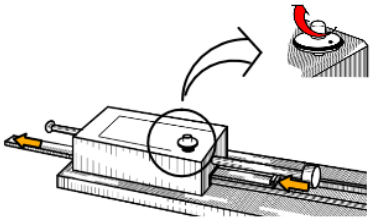


Fig.1

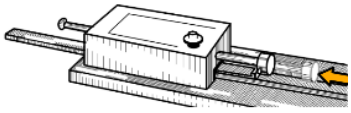


Fig.2

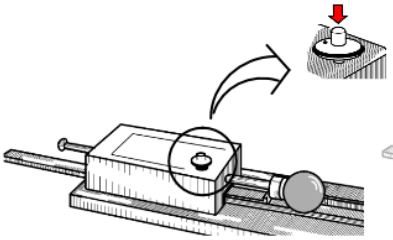


Fig.3

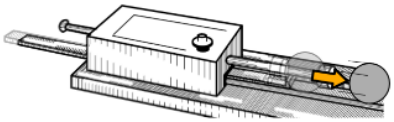


Fig.4

3. Operating Collision Apparatus with BeeSpi v

(1) Set BeeSpi v (a speed measuring device) on BeeSpi v holder (see Fig.5 and 6), after finished setting of the launcher unit (see Operating launcher unit).

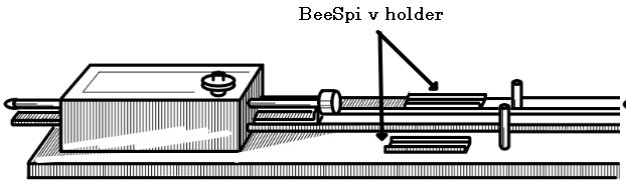


Fig.5

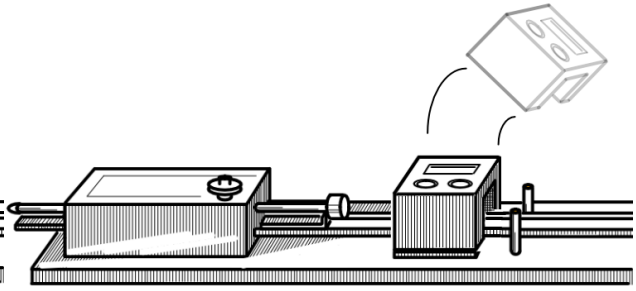


Fig.6

(2) Put the ball in front of LR head (see Fig.7).

(3) Put the wooden block (a target) correctly at the position of launch. The correct position is “0” on the scale tape on the track (see Fig.8).

(4) Push the start button of BeeSpi v for the measuring speed (see the instruction manual of BeeSpi v attached).

(5) Push L button for launching the ball while holding the launcher unit down by your hand, so that the apparatus will not move.

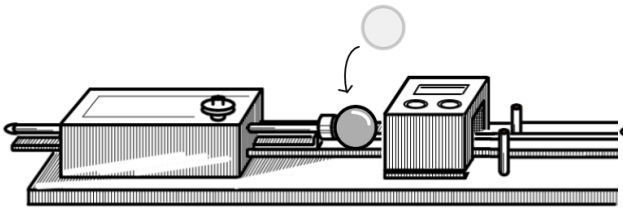


Fig.7

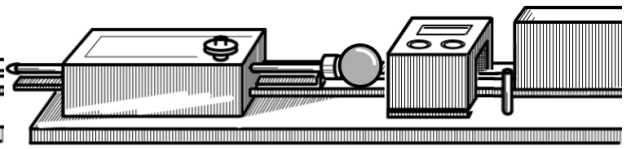


Fig.8

[Caution!]

*The launch position of the ball and position of the wooden block is extremely important for the experiment. If the ball and wooden block is put in wrong position, it may cause bigger dispersion in measurement.

* Hold the launcher unit down at the launch by hand to get a more accurate data.

3. Setup of BeeSpi v

1) Insert two AAA batteries in BeeSpi v after sliding off the battery cover.

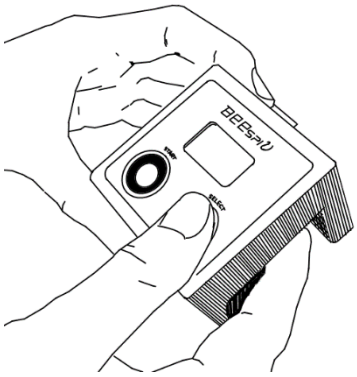
2) Check if four numeric characters, "0" (zero), appears on the LCD display. In case of using BeeSpi v with batteries already inserted, you may find nothing appears on the LCD display, which means it is off. If so, turn the power on by pressing "START" or "SELECT" button.

3) Measurement unit appears at the right edge of the LCD display. Unit of "m/s" is selected for every experiment covered in this teachers' guide. To select the measurement unit, press "SELECT" button for more than two seconds to change the unit in order of "m/s" → "m/h" → "cm/s".

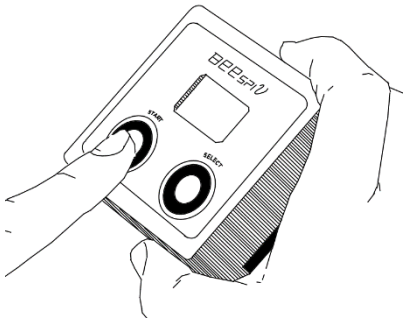
4) Press "START" button to set BeeSpi v into measurement mode after confirming "m/s" unit is appearing on the LCD display.

5) In the measurement mode, BeeSpi v is activated if the selected unit "m/s" is flashing. In this state, speed measurement starts when the first photogate is shielded and ends when the second photogate is shielded by the moving object running through the BeeSpi v.

6) BeeSpi v retains up to five latest measurement results that can be brought up with data number (1~5) at the upper-left of the LCD display by repeatedly pressing "SELECT" button.



SELECT Button:
To activate measurement mode



START Button:
To select unit and retrieve measurement results

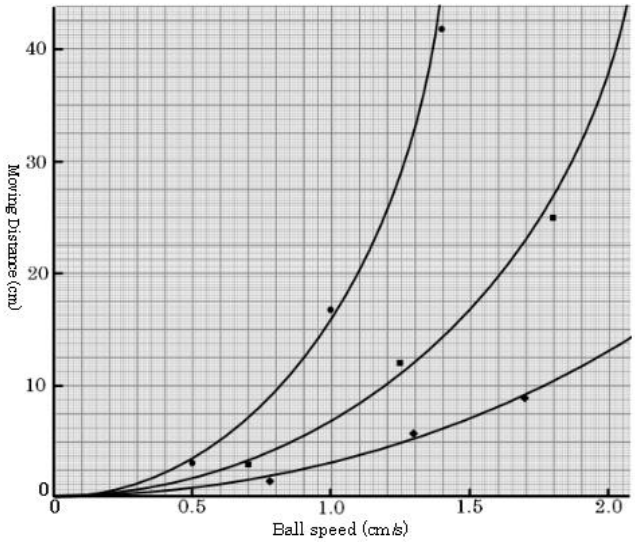
2. Experiment with Confirmation of Kinetic Energy

You may confirm that the kinetic energy (E) is proportional to the square of the velocity using this apparatus.

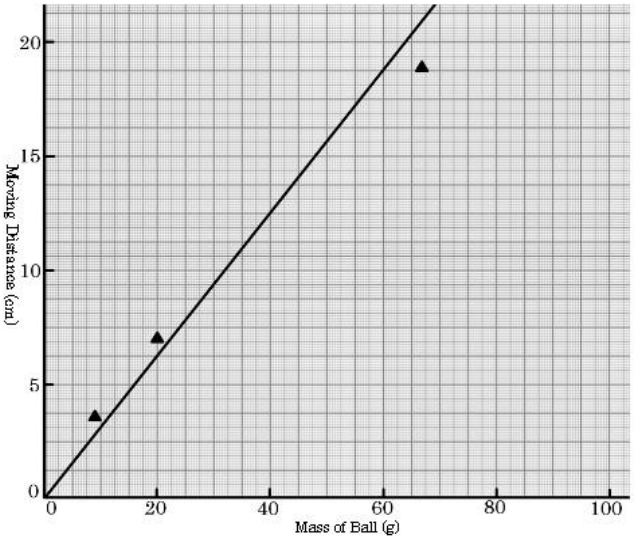
$$E = \frac{1}{2} m v^2$$

In the collision experiment of balls which are the same diameter, different weight (steel, ceramic, and plastic) with a wooden block, you may obtain the moving distance and speed of ball and make Graph 1 of the distance and speed. In the experiment, the moving distance of the ball is proportional to the kinetic energy.

The kinetic energy formula is confirmed by the graph (Quadratic curve). And when speeds of balls are controlled at 1.0 m/s by "Speed adjuster", the relation between the moving distance and the mass may be obtained Graph 2 (Primary curve).



Graph 1



Graph 2

Data of Graph 1

Steel Ball: Mass = 67g

Moving distance of Wooden block(cm)	Speed of Ball (m/s)
3.2	0.5
19.4	1.0
41.9	1.4

Ceramic Ball: Mass = 20g

Moving distance of Wooden block(cm)	Speed of Ball (m/s)
2.91	0.697
12.01	1.251
24.8	1.759

Plastic Ball: Mass = 9.5g

Moving distance of Wooden block(cm)	Speed of Ball (m/s)
1.62	0.782
5.88	1.308
8.86	1.657

Data of Graph 2

	Steel Ball			Ceramic Ball			Plastic Ball	
66.7g	Moving distance of Wooden block (cm)	Speed of Ball (m/s)	20.0g	Moving distance of Wooden block (cm)	Speed of Ball (m/s)	9.5g	Moving distance of Wooden block (cm)	Speed of Ball (m/s)
1	19.2	0.98	1	6.6	0.97	1	3.5	1.01
2	19.1	0.98	2	6.0	0.94	2	3.6	1.02
3	18.5	0.99	3	7.4	1.01	3	3.4	1.02
4	18.2	0.99	4	8.2	1.04	4	3.5	1.01
5	17.9	0.98	5	6.8	0.97	5	3.5	1.01
6	19.5	0.98	6	6.8	0.98	6	3.2	0.97
7	19.0	0.99	7	7.0	0.97	7	3.6	1.02
8	18.9	0.98	8	7.5	0.99	8	3.5	1.02
9	19.3	0.98	9	7.5	0.99	9	3.5	1.03
10	19.3	0.99	10	7.4	0.99	10	3.7	1.03
av.	18.9	0.98	av.	7.1	0.99	av.	3.5	1.01

Table1-1.

Experiment result of relationship between the moving distance and the speed of Steel ball.

Steel Ball	Speed adjuster level 1 (Low Intensity)		Speed adjuster level 2 (Medium Intensity)		Speed adjuster level 3 (High Intensity)	
Mass: 67g	Moving distance of Wooden block(cm)	Speed of Ball (m/s)	Moving distance of Wooden block(cm)	Speed of Ball (m/s)	Moving distance of Wooden block(cm)	Speed of Ball (m/s)
1	3.2	0.51	19.2	0.97	44.7	1.43
2	2.9	0.46	19.1	0.96	44.2	1.41
3	3.4	0.52	18.7	0.99	40.8	1.45
4	3.1	0.52	19.7	0.98	42.2	1.44
5	3.1	0.52	18.0	0.95	42.4	1.42
6	3.5	0.50	20.0	0.97	44.8	1.45
7	3.3	0.52	19.1	0.96	43.1	1.41
8	3.1	0.50	20.3	0.99	40.4	1.41
9	2.9	0.49	19.1	0.91	38.0	1.37
10	3.3	0.51	21.1	0.99	38.4	1.43
Average	3.2	0.51	19.4	0.97	41.9	1.42

Table1-2.

Experiment result of relationship between the moving distance and the speed of Ceramic ball.

Ceramic Ball	Speed adjuster level 1 (Low Intensity)		Speed adjuster level 2 (Medium Intensity)		Speed adjuster level 3 (High Intensity)	
Mass: 20g	Moving distance of Wooden block(cm)	Speed of Ball (m/s)	Moving distance of Wooden block(cm)	Speed of Ball (m/s)	Moving distance of Wooden block(cm)	Speed of Ball (m/s)
1	2.6	0.68	11.8	1.24	26.0	1.78
2	2.5	0.68	12.3	1.25	25.7	1.78
3	3.0	0.70	11.7	1.25	24.9	1.78
4	2.7	0.70	12.1	1.24	23.7	1.74
5	2.8	0.69	11.5	1.26	26.6	1.76
6	3.2	0.71	11.7	1.25	23.7	1.74
7	3.0	0.70	12.2	1.26	23.0	1.75
8	3.3	0.70	12.4	1.26	24.2	1.73
9	2.9	0.70	12.1	1.27	26.3	1.78
10	3.1	0.71	12.3	1.23	23.9	1.75
Average	2.9	0.70	12.0	1.25	24.8	1.76

Table1-3.

Experiment result of relationship between the moving distance and the speed of Plastic ball.

Plastic Ball	Speed adjuster level 1(Low Intensity)		Speed adjuster level 2 (Medium Intensity)		Speed adjuster level 3 (High Intensity)	
Mass: 9.5g	Moving distance of Wooden block(cm)	Speed of Ball (m/s)	Moving distance of Wooden block(cm)	Speed of Ball (m/s)	Moving distance of Wooden block(cm)	Speed of Ball (m/s)
1	1.4	0.75	6.0	1.31	9.2	1.69
2	1.5	0.77	6.0	1.31	7.6	1.68
3	1.5	0.77	5.9	1.29	10.2	1.68
4	1.6	0.78	5.9	1.33	9.0	1.61
5	1.7	0.78	6.0	1.31	9.0	1.63
6	1.7	0.79	6.3	1.31	9.3	1.65
7	1.6	0.79	5.0	1.27	10.4	1.69
8	1.7	0.79	5.7	1.31	7.8	1.77
9	1.8	0.80	6.0	1.31	8.2	1.58
10	1.7	0.80	6.0	1.33	7.9	1.59
Average	1.6	0.78	5.9	1.31	8.9	1.66