Resultant Force

NaRiKa Corporation

1. Learning Outcomes

It is the purpose of this experiment guide to help learners, through experiments, understand the scientific concepts on Resultant Force, as well as Vector to represent Resultant Force. Conventionally, learners learn the topics of Resultant Force and Vector out of their textbooks without conducting experiments. As opposed to such conventional learning method, this experiment guide is intended for learners to measure the strength of each of two forces in different directions by using a Newton meter (A05-4065).

Consequently, based on measured results of experiments learners will be able to describe the concept of Resultant Force through their interpretation and analysis.

2. Introduction of Equipment for Experiments

1. Newton Meter

Spring balances with divisions based on the SI unit (the international system of units) called newton (N) has been commonly used for the topic of “Force and Motion” such as "composition (addition) and decomposition (resolution) of forces," "balance of forces," and "action and reaction". Experiments in this guide use Newton Meter, of which measurement range is ±19.99 N (with 0.01 N resolution). Notably, the minimum scale is as fine as 0.01N over the whole measurement range (see the instruction manual for more information).

A05-4065　Digital Newton Meter GN-1

Minimum scalable divisions differ by the type of spring balances (see Table 1). Therefore, learners must select suitable spring balance depending on experiment objectives and/or mass of the object to measure. On the other hand, Newton Meter saves their time for preparation because of the wider measurement range compared to spring scale, as well as the consistent minimum scale over the whole measurement range.

Table 1. Newton Meter vs. Newton Spring Scale (SO series)

Newton Meter GN-1			Spring balance		
Cat. No.	Measurement range	Resolution	Cat. No.	Measurement range	Minimum scale
A05-4065	- 19.99 ~ + 19.99 N	0.01 N	A05-4053-W1	0 ~ 2 N	0.02 N
			A05-4053-W2	0 ~ 5 N	0.05 N
			A05-4053-W3	0 ~ 10 N	0.1 N

Additionally, most of commonly available Newton scales are designed to measure strength of pulling forces only. In contrast, Newton Meter measures both pushing and pulling forces.

3. Resultant Force

1. Purpose of this experiment:

In this guide, learners will measure strength of each of two forces in different directions applied to a spring placed on a graph paper or a magnetic whiteboard. At this time, learners will physically and directly annotate measured strength of each force in Newton unit (N) on the action line of the force drawn on a graph paper or a magnetic whiteboard. Then they will draw arrows to represent measured strengths of the forces with an appropriate scale on a graph paper or a magnetic whiteboard. They will finally understand the concept of Resultant Force after analyzing the polygon made up with the arrows.

2. What to prepare:

*A05-4065 Newton Meter GN-1: 2~3 units
*Spring: φ8~15 mm x 30~60 mm: 1 pc
*Strings: 50 ~ 70 mm length: 2 pcs
*Magnet pin: 1 pc (or Cellophane tape: Moderate amount)
*Marker pen or Pencil: 1 pc
*Ruler: 300 mm length: 1 pc
*Whiteboard or Graph paper: 300~420 x 420 ~ 600 mm: 1 pc

Shape the strings into a ring. Fishing line is recommended and avoid using stretchable string. Use a magnet pin to affix a spring on a magnetic whiteboard, while use a cellophane tape to affix on a graph paper.

3. Experiment

3-1. Experiment setting

3-1-1. Draw a straight line with a marker on a graph paper or a magnetic whiteboard. Put a mark on the line at about one-third the width of the graph paper or the whiteboard from one of its edges. Then, mark the point “O” on the center of the line (See Fig. 1).

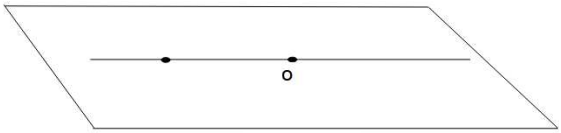

Fig. 1

3-1-2. Draw two lines from the point “O” as shown in Fig. 2.

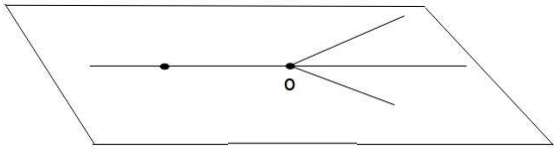

Fig. 2

3-1-3. Affix one edge of a spring on the mark (see 3-1-1.) with cellophane tape or hook it on a magnet pin put on a magnetic whiteboard. Hook each string to the other edge of the spring. Then, hook two Newton Meters to the other edge of each string as shown in Fig. 3.

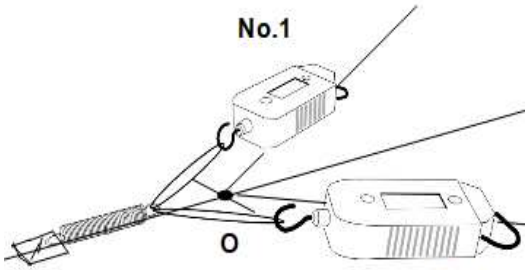

Fig. 3

3-2. Experiment of Resultant Force measurement

3-2-1. Press the "ON/OFF" button on each Newton meter for two seconds to turn the meter on. Check if numeral "0" is shown on each screen. If not, press the button again. As needed, press zero-calibration button to calibrate.

3-2-2. Slowly pull each of the Newton Meters (No. 1 and No. 2) along either of the two lines extending from the point “O” until the edge of the spring reaches the point “O” as shown in Fig. 4 and Fig. 5.

3-2-3. Once the edge of the spring reaches the point “O”, press the "HOLD" button on each meter. Annotate the values displayed on each of the two meters directly on the graph paper, and then fill those values in Table 1.

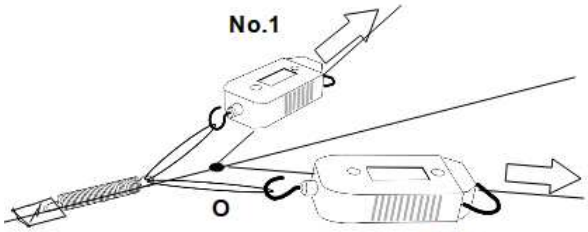

Fig. 4

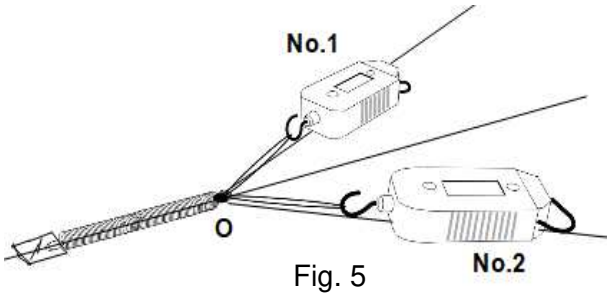

Fig. 5

3-2-4. Remove both Newton Meters from the strings. Hook one of the two Newton Meters to the strings and move the Newton Meter (No. 3) along the line extending from the point “O” until the

edge of the spring reaches the point “O” as shown in Fig. 6 and Fig. 7. Once the edge of the spring reaches the point “O”, press the "HOLD" button on the Newton meter. Annotate the value (to be represented as C) displayed on the Newton meter directly on the graph paper, and then fill the value in Table 1.

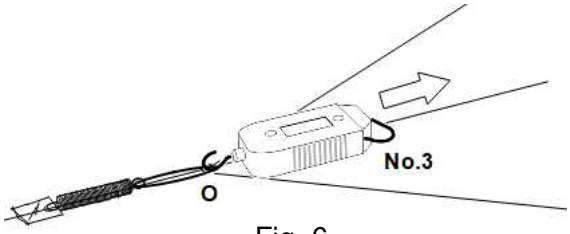

Fig. 6

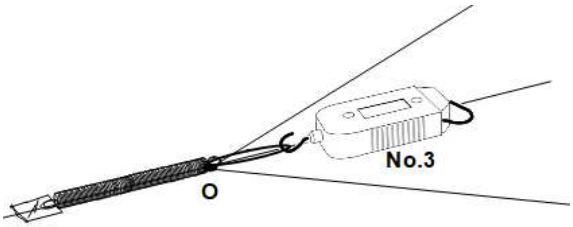

Fig. 7

3-2-5. Convert the measured values filled in Table 1 to the corresponding values in the unit of length by using a scale of 1cm to represent 0.1N, and then fill those converted values A, B and C in Table 1.

Table 1. Measured values and converted values

Newton Meters	Measured values	Converted values
No. 1	N	A cm
No. 2	N	B cm
No. 3	N	C cm

3-2-6. Put dots of “A”, “B” and “C” on the graph paper respectively at each converted distance from the point “O” filled in Table 1. Then, draw arrows from the point “O” to each of the points of “A”, “B” and “C” to make the line segments OA, OB and OC as shown in Fig. 8.

3-2-7. Finally, draw the line segments AC and BC as shown in Fig. 9.

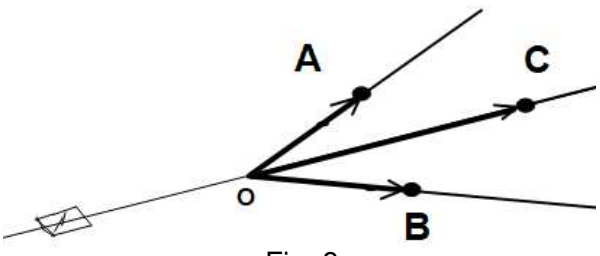

Fig. 8

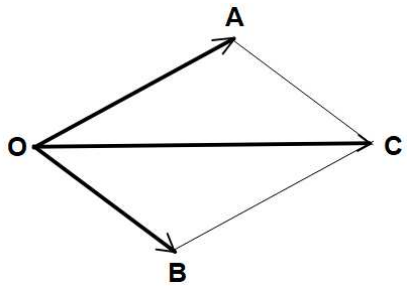

Fig. 9

4. Questions

4-1. Which of the line segments represents the Resultant Force?

☐ Line segment OA ☐ Line segment OB ☐ Line segment OC

4-2. What kind of (polygonal) shape do you think can be drawn after the experiment?

4. Summary

Through the experiments in this guide, learners will understand that the Resultant Force of two forces in different directions is represented by (the diagonal of) the parallelogram completed with strengths (represented by line segments) and directions (represented by arrows) of the two forces using an appropriate scale. This will also help learners understand the scientific concept of vector.

Note that the same spring has to be used when measuring strengths of all the forces generated throughout entire experiments to keep the scale of its length unchanged. It is also crucial to complete a parallelogram using lengths converted form measured strengths of forces. Appropriate instruction is needed for each learner who draws lines and completes a parallelogram using each distance between the point "O" and the edge(s) of the Newton Meter(s).