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Novel Third-Law Demonstration

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Here is an easy way to demonstrate Third-Law interactions using identical "button" magnets[1] sliding along a smooth (non-magnetic) knitting needle.[2] Thread the magnets over an ordinary aluminum knitting needle, with like poles facing each other. Up to five or six magnets suitably arranged demonstrate the desired physics nicely. The demonstration can be conducted for two orientations of the "line of action": horizontal and vertical.

In the first case, gravitational interaction can be ignored because it does not act along the line of action. In the second case, gravitational interaction combines with the magnetic to constitute a more challenging situation. In both cases the magnets are arranged so that the closest neighbors repel each other.

Case 1: Horizontal Constraint

If the knitting needle is held horizontally, the magnets will arrange themselves with equal spacing. (The surface of the knitting needle is quite smooth, although a light tapping may be needed to overcome any residual "sticking.") Invite your audience to consider the forces on any one of the magnets. If the demonstration is begun with only two magnets repelling each other, then it is quite clear from the behavior of the magnets that there is an "equal and opposite" force on each of them; in other words, there are action-reaction force-pairs—just as Newton predicted!

If a third magnet is added, as in Fig. 1, in addition to the action-reaction force-pairs between the hands and magnets #1 and #3, there is also an action-reaction magnetic force-pair between #1 and #2 as well as between #2 and #3.

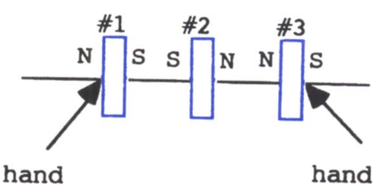

Fig. 1.

Case 2: Vertical Constraint

If you hold the knitting needle upright so the magnets are constrained to move along a vertical line, then the situation becomes more complicated; now there is a gravitational interaction along with the original magnetic and constraint interactions. Beginning with just one magnet, invite your audience to analyze the situation in terms of a single action-reaction force-pair wherein the gravitational interaction between the mass of the magnet and the ambient gravitational field is just balanced by the constraint force supplied by the hand.

Next, as shown in Fig. 2, add two additional magnets that are oriented to produce repulsive magnetic interaction between closest neighbors. The uneven spacing between the magnets when constrained to move vertically rather than horizontally provides the opportunity to apply Newton's Third Law to a situation involving simultaneous effects of two kinds of interaction.

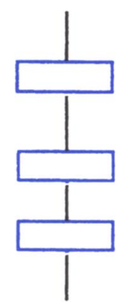

Fig. 2.

The combination of "button" magnets and knitting needles—nothing more!—provides an entertaining and instructive demonstration of action-reaction force pairs, rather vividly illustrating Newton's Third Law. The cost is low enough so that an entire class of students—working in groups of three or so—could perform the experiment during a regular class period.

References

1. Available from Science City, 50 Bloor Street West, Toronto, ONT M4W 1A1 Canada. A bag of ten is priced at $1.99 ($CAN). The magnets are 8 mm in diameter and 5 mm thick. The hole is just over 2 mm in diameter.
2. Such knitting needles are quite commonly available with a diameter of 2 mm. They appear to be coated or perhaps anodized and feel quite smooth.