

# Long Range Repulsion, Short Range Attraction

Part of a Series of Activities in Plasma/Fusion Physics  
to Accompany the chart  
*Fusion: Physics of a Fundamental Energy Source*

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Prepared with support from the Department of Energy, Office of Fusion Energy Sciences,  
Contract #DE-AC02-76CH03073.

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## Preface

This activity is intended for use in high school and introductory college courses to supplement the topics on the Teaching Chart, *Fusion: Physics of a Fundamental Energy Source*, produced by the Contemporary Physics Education Project (CPEP). CPEP is a non-profit organization of teachers, educators, and physicists which develops materials related to the current understanding of the nature of matter and energy, incorporating the major findings of the past three decades. CPEP also sponsors many workshops for teachers. See the homepage [www.CPEPweb.org](http://www.CPEPweb.org) for more information on CPEP, its projects and the teaching materials available.

The activity packet consists of this student activity and separate notes for the teacher. The Teacher's Notes include background information, equipment information, expected results, and answers to the questions that are asked in the student activity. The student activity is self-contained so that it can be copied and distributed to students. Teachers may reproduce parts of this document for their classroom use as long as they include the title and copyright statement. Page and figure numbers in the Teacher's Notes are labeled with a T prefix, while there are no prefixes in the student activity.

Developed in conjunction with the Princeton Plasma Physics Laboratory and funded through the Office of Fusion Energy Sciences, U.S. Department of Energy, this activity has been field tested at workshops with high school and college teachers.

We would like feedback on this activity. Please send any comments to:

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## Long Range Repulsion, Short Range Attraction

### Part of a Series of Activities in Plasma/Fusion Physics to Accompany the chart *Fusion: Physics of a Fundamental Energy Source*

**Materials:** A pair of neodymium or cobalt-samarium disc magnets, a steel rod, two steel machine nuts, and a steel ball bearing

#### Procedures:

1. Holding on very tightly to the two disc magnets, one in each hand, bring the flat sides of the two magnets toward each other. You should feel the effects of either an attractive or a repulsive force. Reverse one of the magnets to reverse the effect. In the case of the repulsive effect, slowly bring the magnets toward each other until they touch. You will have to hold them very firmly to do this.

Does the effect ever become attractive?

2. While firmly holding the two magnets, locate two sides that repel as in the previous procedure. Hold the two magnets far apart, but keep the repelling sides (called like magnetic poles) toward each other. Maintaining this alignment, place the steel rod between the two magnets so that each end of the bar is near a magnet (see Figure 1). Slowly bring the magnets closer to the ends of the rod until one, then the other, touches the rod.



**Figure 1:** A steel rod between two strong magnets

Does the effect ever become repulsive? Do this a few times to be sure.

3. Again locate two repelling poles of the magnets. Separate these poles, but keep them toward each other. Maintaining this alignment, place the ball bearing against one of the repelling poles while the other magnet is several centimeters away from the ball bearing (see Figure 2). Slowly and carefully bring the second magnet toward the ball bearing until contact is made. Do this several times to be sure of what is happening.



**Figure 2:** Magnet approaching a ball bearing on a magnet

How is the result like that of the repulsive part of Procedure 1? How is it like that of Procedure 2? Can the results be explained in terms of what happened in the previous procedures?

4. Again locate two repelling poles. Separate these poles, but keep them toward each other. Maintaining this alignment, place both machine nuts flat against one of the repelling poles while the other magnet is several centimeters away from the machine nuts (see Figure 3). Slowly and carefully bring the second magnet directly toward the machine nuts until contact is made.



**Figure 3:** Magnet approaching two machine nuts on a magnet

Were there any surprising results? If not, try again, and move more slowly. Would the same forces which acted within the ball bearing in the previous procedure cause the machine nuts to separate in this one?

**Questions:**

1. How many magnetic poles are induced in a ball bearing in contact with a single magnet?

2. How many poles were induced in the steel rod when both magnets were in contact with its ends? Where along the rod might these poles be located?

3. What evidence do you have that the same number of poles was at times induced in the ball bearings and in the pair of machine nuts as in the steel rod? Where would these poles be in the ball bearings and in the pair of machine nuts?

4. Would you view the ball bearing with both magnets against it as a tripole or as a quadrupole? Why?

5. For nuclear fusion to take place the long range electrical repulsion between nuclei must be overcome by a short range nuclear force attraction. If this didn't happen:

a. could stars come into existence gravitationally?

b. could stars radiate large amounts of energy fairly continuously for billions of years?

c. could massive elements form in stars?

6. What would the night sky look like if objects that repel at some separations did so at all separations?