PHYSICS IN MOTION
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Unit 7C

Name: **Date:**

Nuclear Fusion

Physics of a Fundamental Energy Source Lab

Nuclear fusion between nuclei occurs in stars at very high temperatures. On Earth, nuclear fusion is a potential clean energy source, one that could revolutionize how energy is generated. Currently, there are limitations on nuclear fusion as an energy source, as extremely high temperatures are required for these nuclear fusion reactions to take place.

Nuclear fusion involves the nuclei of two atoms, which are both positively charged, combining to form a new, heavier nucleus. The nuclei are positively charged and repel each other, but very high temperatures provide them with enough kinetic energy to overcome electrical repulsion and combine together.

In today's activity, we will be modeling the fusion mechanism with a focus on the three requirements for fusion to occur:

- **Fuel**
- **High temperatures**
- **Time**

The <u>fuel</u> will be represented by the red and black checkers.

The red checkers will represent the hydrogen isotope called deuterium, and the black checkers will represent the hydrogen isotope called tritium. Deuterium and tritium are both hydrogen because they each have one proton, but deuterium has one neutron and tritium has two. The fusion of these two isotopes is the most common nuclear fusion reaction conducted by scientists.

The <u>temperature</u> will be represented by how vigorously you shake the reaction vessel.

The temperature of a substance relates to the average kinetic energy of the molecules in the substance, so the higher the temperature, the faster the molecules will move.

The final requirement is <u>time</u>, and that will be represented by, obviously, time.

The first relationship we will be exploring is between the number of reactions and the simulated temperature, with time being held constant. Start with an equal number of checkers of each color in your bag, and change the rate at which you shake the reaction vessel (bag). A reaction occurs when two checkers of different colors stick together or fuse. Keep the time that the nuclei react constant, around 10 seconds, and count the number of reactions that take place. Do this for five different shaking frequencies.

Text adapted from *Fusion: Physics of a Fundamental Energy Source*

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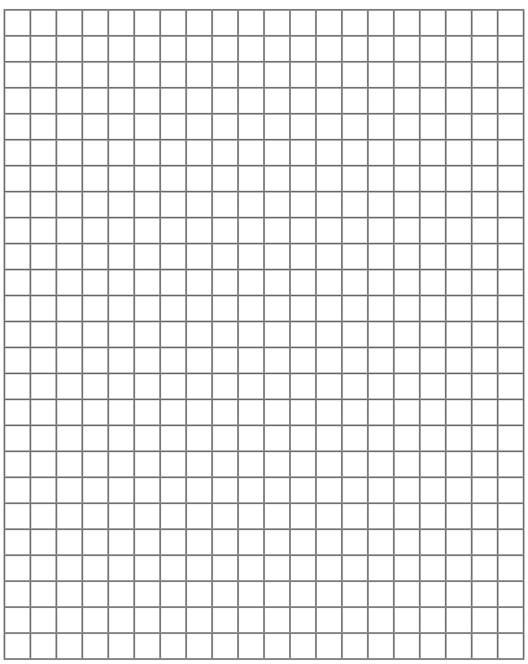
Your data table should have a column for the shaking frequency (frequency = # shakes divided by total time) and a column for the number of reactions that takes place. Graph the number of complete reactions on the y-axis, and the frequency of the shakes on the x-axis.

The second relationship we will be exploring is between the number of fusion reactions and the time the reactions take place, with the "temperature" held constant. Again, start with an equal number of checkers of each color in your bag. This time, change the amount of time that the bag will be reacting. Keep the rate of shaking constant so as to mimic a constant temperature in the reaction vessel. Do this for five different time periods.

Your second data table should have a column for the reaction time and a column for the number of reactions that takes place. Graph the number of reactions on the y-axis and the reaction time on the x-axis.

Number of Complete Reactions vs. Frequency of Shakes

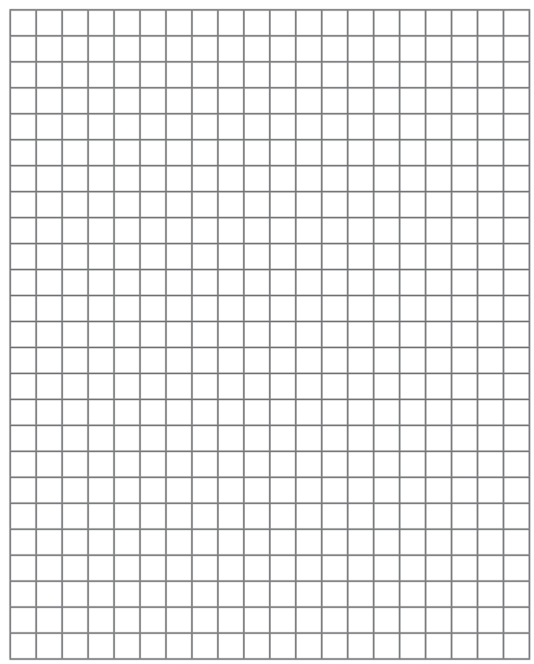
Number of Complete Reactions (Reactions)



Frequency (shakes/second)

Number of Complete Reactions vs. Reaction Time

Number of Complete Reactions (Reactions)



Reaction Time (seconds)

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Questions to Consider for Part 1

1. How does the number of reactions change as the frequency of shaking changes?

2. Does the graph of the number of reactions versus the "temperature" show a linear or nonlinear relationship?

3. How does the number of reactions change as the reaction time changes?

4. Does the graph of the number of reactions versus the reaction time show a linear or nonlinear relationship?

5. The other factor for nuclear reactions is the concentration of fuel, in this case, the checkers representing deuterium and tritium. Based on your results, do you predict the number of reactions will increase if the number of checkers increases? Or will the number of reactions increase if the number of checkers remains the same, but the reaction vessel is smaller? Explain your reasoning for each question, and attempt each situation to verify your results.