

Ion Propulsion

Attractive and Repulsive Forces in Ion Propulsion Engines

STUDENT ACTIVITY

This activity was designed to be completed individually or in pairs at a computer with Internet access. However, your instructor may have you collect the data and complete the tables in the Student Activity Report Sheet using a different method with a different procedure.

Part 1 Procedure

1. Go to http://dawn.jpl.nasa.gov/mission/ion_engine_interactive/index.html and read the information about ion engines.
2. Click on [Positive and Negative Charges](#). Complete the eight Test Charge exercises. As you do this, look for answers to the following questions:

What is the effect of placing a **negatively** charged particle close to the path of the positive test charge?

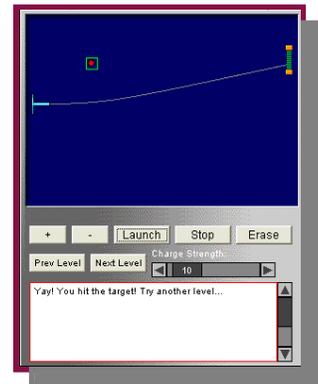
How does the distance of the **negatively** charged particle from the undeflected path of the test charge affect the path of positive test charge?

How does an increase in the charge of the **negatively** charged particle affect the path of the positive test charge?

What is the effect of placing a **positively** charged particle close to the path of the positive test charge?

How does the distance of the **positively** charged particle from the undeflected path of the test charge affect the path of positive test charge?

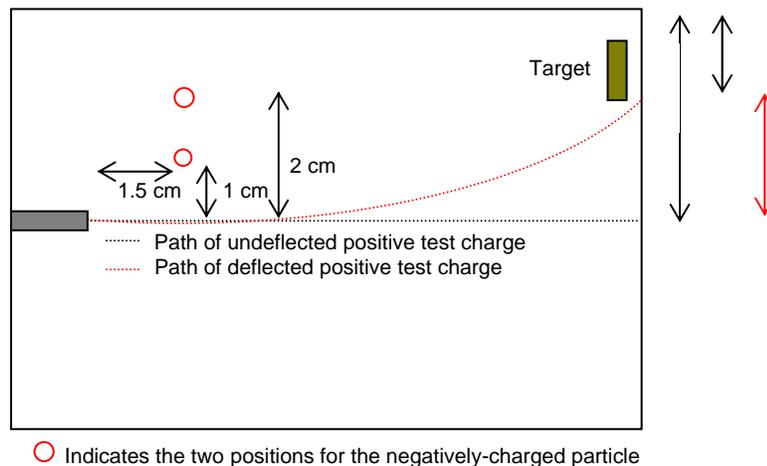
How does an increase in the charge of the **positively** charged particle affect the path of the positive test charge?



Part 2 Procedure

- Obtain a small paper or plastic metric ruler from your instructor.
- Go to the Menu screen and click on [Charge Simulator](#) and conduct the following experiment using only the first screen in this simulation:

Measure the length and height of the rectangle on the screen. If you are taking measurements on a monitor without a rigid plastic screen, do this carefully so that you don't damage the monitor screen. Record the measurements on the diagram below. (Don't forget that measurements have units.) Now that you have made your initial readings on this computer and monitor, you must use this equipment to make all your Part 2 measurements.



- Click on the "Launch" button and measure the distance from the top of the rectangle to where the undeflected positive test charge goes off the screen. Record the distance on the diagram above.
- Click on the "-" button. This should add a negatively-charged particle (red circle) to the screen.
- Click and drag the particle so that it is 1.5 cm from the end of the test charge launcher and 1 cm above the path of the undeflected positive test charge. In the diagram above, this is the lower red circle.
- Adjust the Charge Strength slider to 5.
- Click on the "Launch" button and measure the distance from the top of the rectangle to the point where the positive test charge left the screen. Record the distance in the third row, fourth column in the table below.
- Subtract the distance measured in step 9 from the distance of the undeflected positive test charge from the top of the screen, which was measured in step 5 above. Record this difference in the third row, fifth column of the table below.
- Adjust the Charge Strength slider to 10 and repeat steps 9 and 10.
- Move the negatively-charged particle so that it is 1.5 cm from the end of the test charge launcher and 2 cm above the path of the undeflected positive test charge. In the diagram above, this is the upper red circle.
- Repeat procedure steps 8 through 11.

14. Answer the following questions regarding the data you collected.
- At a distance of 1.5 cm from the end of the test charge launcher, which factor had the greater effect on the deflection path—doubling of the negative charge on the particle or doubling the distance of the negative particle from the undeflected test charge path?
 - Based on what you know about attractive and repulsive forces, what could be the reason for the answers to a) above?
 - How do you predict the deflection paths would change if you used positively charged particles of the same strengths and positioned in the same locations?

Part 3 Procedure

- Go to the Menu screen and click on [Charge Simulator](#) and conduct the following experiment using only the first screen in this simulation. Remember that all your measurements should be completed on the same computer.
- Click on the “Launch” button and measure the distance from the bottom of the rectangle to where the undeflected positive test charge goes off the screen. Record the distance on the diagram above.
- Complete the data table below by repeating steps 6 through 12 of the Part 2 Procedure using a **positively** charged particle.

Anticipated results for negatively-charged particle

Location of negatively-charged particle		Charge on negative particle	Distance from top of screen	Deflection from path	Change in deflection
From end of gun	Above the undeflected path				
1.5 cm	1 cm	5	18	9	Doubling charge 1.5 cm/1 cm =17/9 = 1.88
1.5 cm	1 cm	10	10	17	
1.5 cm	2 cm	5	24	3	
1.5 cm	2 cm	10	20	7	

Anticipated results for positively-charged particle

Location of positively-charged particle		Charge on positive particle	Distance from bottom of screen	Deflection from path
From end of gun	Above the undeflected path			
1.5 cm	1 cm	5	23	7
1.5 cm	1 cm	10	16	14
1.5 cm	2 cm	5	25	5
1.5 cm	2 cm	10	22	8