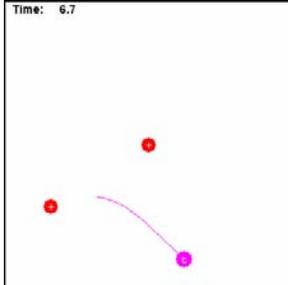


## Worksheet for Exploration 22.2: Explore the Effect of Multiple Charges



A positive test charge is shown in the animation. You can add positive and/or negative charges. All charges are added to the middle of the animation so you must drag each newly added charge to a new location. When you push play, the test charge will move under the influence of the forces from the other charges.

*Note that the test charges are movable due to the net force of all other “dragable” charges. The dragable charges that you add are “NAILED” into position where you leave them.*

- a. Add one positive charge. Describe and explain the motion of the test charge.
  - i. Make sure you compare what happens to force or acceleration as time passes (or as the test charge gets further away).
  
- b. How can you tell from its motion that the test charge experiences a force, but that the force decreases as the test charge moves away from the positive charge?
  
- c. What do you predict the motion will be if the positive charge is replaced by a negative charge?
  
- d. Clear the screen and try it. Was your prediction correct?
  
- e. How can you configure two charges of the same sign and keep the test charge stationary? Describe your configuration.
  - i. Sketch what you think this configuration should look like, and include information about distances of the test charge from the other charges.
  - ii. After sketching try to set up your configuration. Make sure you wait a long time to see if you can establish this “equilibrium” condition. Can you?

- f. What happens if you move one of the charges slightly? *This is a demonstration of an unstable equilibrium point (like a gymnast on a balance beam; a nudge one way or the other and she will fall).*
- g. Design and describe a configuration in which the test charge will oscillate back and forth.
- i. You want to set it up so that no collision occurs. Discuss any difficulties you may have setting up your configuration. Give a sketch of your configuration.
- h. Explain why (in terms of the forces) the test charge oscillates in your configuration.
- i. What requirements must you satisfy to obtain that oscillatory motion?
- i. Clear the charges and add one negative charge. Let the test charge start moving (so it has an initial velocity) and then move the negative charge around so that the test charge orbits the negative charge. Explain (in terms of forces) why it orbits.