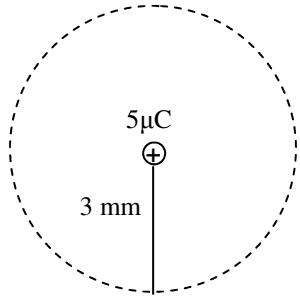


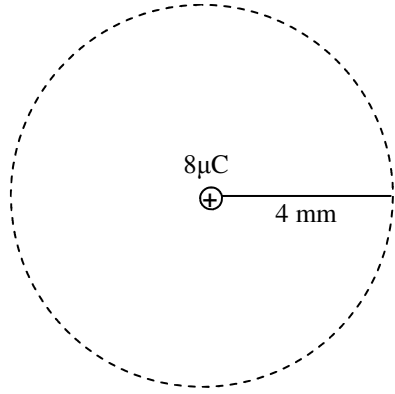
Name: \_\_\_\_\_

Period: \_\_\_\_\_

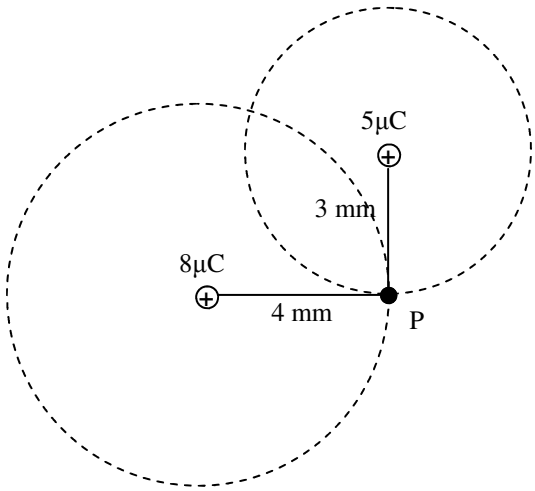
**Calculating net E, F, PE, and V page 2**



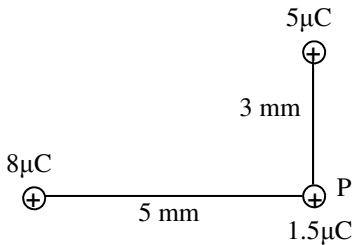
1. Calculate the four electrostatic quantities (E, F, PE, and V) 3 mm from a  $5\mu\text{C}$  charge, as shown in the diagram. Be sure to give direction, if necessary. Some may be zero. Notice, keeping  $r$  constant produces a sphere that is 3 mm away from the  $5\mu\text{C}$  charge. This means E, F, PE, and V will have particular values everywhere on that sphere.



2. Calculate the four electrostatic quantities 4 mm from an  $8\mu\text{C}$  charge, as shown in the second diagram. Again, everywhere equidistant from the charge will have the same E, F, PE, and V.



3. The two charges are then brought close to each other. Obviously, their spheres intersect at a few points (two should be obvious). Each of these points is 3 mm from one and 4 mm from the other. We will call one of these intersections points P. Using the numbers you found in Q1 and 2, calculate the net E, F, PE, and V at point P due to both charges. Again, some may be zero.



4. A  $1.5\mu\text{C}$  charge is then brought to point P from infinity. The spheres have been removed to make the diagram easier to read.  
A. Again, using your previous numbers, calculate the four electrostatic quantities for this charge at point P.

B. How much work was done to move the charge to point P from infinity?

C. If released from rest, which way will the  $1.5\mu\text{C}$  move?

D. If a negative charge was put at P, which way would it move?

5. The  $1.5\mu\text{C}$  charge is then replaced with a  $3\mu\text{C}$  charge.  
A. How would the electric field at P change?  
B. How would the force at P change?  
C. How would the electric potential (V) at P change?  
D. How would the potential energy at P change?

6. The  $1.5\mu\text{C}$  is returned and the  $5\mu\text{C}$  charge is changed to a  $-5\mu\text{C}$  charge. Describe any changes that will occur on the charge at P.

Name: \_\_\_\_\_

Period: \_\_\_\_\_

## Calculating net E, F, PE, and V page 2

$\vec{E} = k \frac{(5 \mu\text{C})}{(3 \text{ mm})^2} = 5 \times 10^9 \text{ N/C down}$   
 $\vec{F} = \frac{kqQ}{r^2} = 0 \text{ N}$  (only 1 q)  
 $V = \frac{kq}{r} = \vec{E}r$   
 $V = 5 \times 10^9 (3 \text{ mm})$   
 $= 15 \times 10^6 \text{ J/C}$   
 $= 1.5 \times 10^7 \text{ J/C}$  (no direction)  
 $PE = 0 \text{ J}$  (only 1 q)

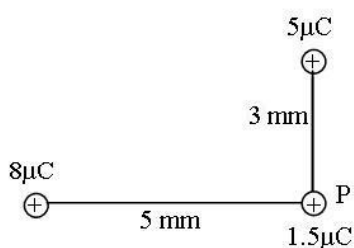
1. Calculate the four electrostatic quantities (E, F, PE, and V) 3 mm from a  $5 \mu\text{C}$  charge, as shown in the diagram. Be sure to give direction, if necessary. Some may be zero. Notice, keeping r constant produces a sphere that is 3 mm away from the  $5 \mu\text{C}$  charge. This means E, F, PE, and V will have particular values everywhere on that sphere.

$\vec{E} = k \frac{(8 \mu\text{C})}{(4 \text{ mm})^2}$   
 $= 4.5 \times 10^9 \text{ N/C}$   
 to R  $\rightarrow$   
 $\vec{F} = 0 \text{ N}$  (only 1 q)  
 $V = Er$   
 $= 1.8 \times 10^7 \text{ J/C}$   
 $PE = 0 \text{ J}$

2. Calculate the four electrostatic quantities 4 mm from an  $8 \mu\text{C}$  charge, as shown in the second diagram. Again, everywhere equidistant from the charge will have the same E, F, PE, and V.

obviously  $\vec{F}$  and PE are still 0, since there is no q at point P.  
 $V_{\text{net}}$  is scalar, so just add  $= (1.8 + 1.5) \times 10^7$   
 $= 3.3 \times 10^7 \text{ J/C}$   
 $\vec{E}_{\text{net}}$  is a vector, so  
 $\vec{E}_{\text{net}} = \sqrt{5^2 + 4.5^2}$   
 $= 6.7 \times 10^9 \text{ N/C}$   
 $\theta = \tan^{-1} \left( \frac{-5}{4.5} \right) = -48^\circ$   
 and since x and y are almost  $= \theta$  must be close to  $45^\circ$ .

3. The two charges are then brought close to each other. Obviously, their spheres intersect at a few points (two should be obvious). Each of these points is 3 mm from one and 4 mm from the other. We will call one of these intersections points P. Using the numbers you found in Q1 and 2, calculate the net E, F, PE, and V at point P due to both charges. Again, some may be zero.



$\vec{E}_{\text{net}} = 6.7 \times 10^9 \text{ N/C}$   
 mult. by C to get N:  
 $\left( \frac{6.7 \times 10^9 \text{ N}}{1 \text{ C}} \right) \frac{1.5 \mu\text{C}}{1} = 1.005 \times 10^4 \text{ N at } -48^\circ$   
 $PE = qV = 3.3 \times 10^7 \text{ J/C} (1.5 \mu\text{C})$   
 $PE = 49.5 \text{ J} (V \text{ still} = 3.3 \times 10^7 \text{ J/C})$

4. A  $1.5 \mu\text{C}$  charge is then brought to point P from infinity. The spheres have been removed, only to make the diagram cleaner.

A. Again, using your previous numbers, calculate the four electrostatic quantities for this charge at point P.

- B. How much work was done to move the charge to point P from infinity?

49.5 J (and will have 49.5 J of KE after it is released)

- C. If released from rest, which way will the  $1.5 \mu\text{C}$  move?

+ charges go the direction of E ( $-48^\circ$ ), since we used a + test charge

- D. If a negative charge was put at P, which way would it move?

- charges go the opposite direction of E (toward the 2nd Q)

5. The  $1.5 \mu\text{C}$  charge is then replaced with a  $3 \mu\text{C}$  charge.

- A. How would the electric field at P change?  
No  $\Delta$ , since the  $8 \mu\text{C}$  +  $5 \mu\text{C}$  haven't changed
- B. How would the force at P change?  
doubles:  $F = qE$  and q doubled
- C. How would the electric potential (V) at P change?  
no  $\Delta$
- D. How would the potential energy at P change?  
doubles

6. The  $5 \mu\text{C}$  charge is changed to a  $-5 \mu\text{C}$  charge. Describe any changes that will occur on the charge at P.

$\vec{E}$  has same mag, but toward 1st Q.  
 $\vec{F}$  is same mag (same  $\vec{E}$ ) at  $+48^\circ$   
 $V$  in Q1 is now neg, so  
 $V_{\text{net}} = (-1.5 \times 10^7) + (1.8 \times 10^7) = 3 \times 10^6 \text{ J/C}$   
 so  $PE = qV = 1.5 \mu\text{C} (3 \times 10^6) = 4.5 \text{ J}$