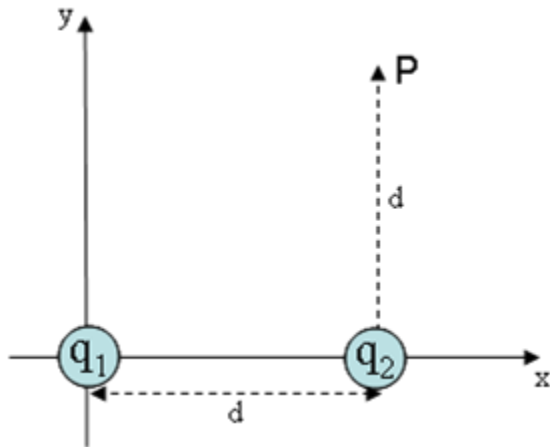


Electric Field from Point Charges



Two point charges ($q_1 = -4.2\mu\text{C}$ and $q_2 = 6.1\mu\text{C}$) are fixed along the x-axis, separated by a distance $d = 9.3$ cm. Point P is located at $(x,y) = (d,d)$.

1)

What is $E_x(P)$, the value of the x-component of the electric field produced by q_1 and q_2 at point P?

-1.545E6

N/C

The electric field equation for a point charge is:

$$\mathbf{E} = \frac{kQ}{r^2} \hat{r}$$

To find the electric field from several point charges we can use superposition and just add the E field contributions separately. To find the net field in the x direction we just sum the individual x axis contributions.

$$E_{net\ x} = E_{1\ x} + E_{2\ x} = E_1 \cos\theta + 0$$

2)

What is $E_y(P)$, the value of the y-component of the electric field produced by q_1 and q_2 at point P?

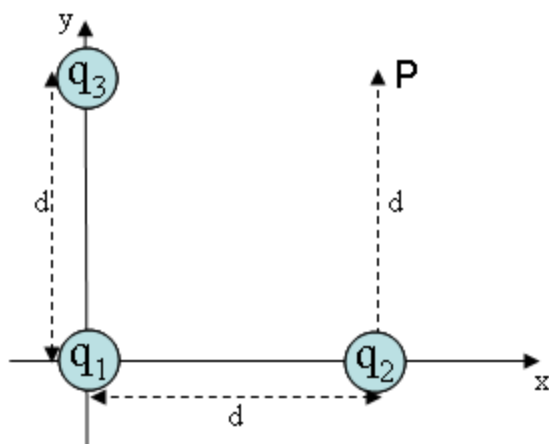
4.803E6

N/C

The Y component uses the same idea:

$$E_{net\ y} = E_{1\ y} + E_{2\ y} = E_1 \sin\theta + E_2 \sin\theta$$

3)



A third point charge $q_3 = 3.2 \mu\text{C}$ is now positioned along the y-axis at a distance $d = 9.3 \text{ cm}$ from q_1 as shown. What is $E_x(P)$, the x-component of the field produced by all 3 charges at point P?

1.78E6 N/C

By superposition we know that the new E field in the X direction is just the answer from (1) plus the X-component of E_3 , which in this case will be the entire value of E_3 .

4)

Suppose all charges are now doubled (i.e., $q_1 = -8.4 \mu\text{C}$, $q_2 = 12.2 \mu\text{C}$, $q_3 = 6.4 \mu\text{C}$), how will the electric field at P change?



Its magnitude will double and its direction will remain the same

The field we calculated depends on the magnitude of the individual charges and they're distances from P. If we double each of the charges then that has the net effect of doubling the whole thing but doesn't change how strong they are compared to each other and thus doesn't change the net field direction.

5)

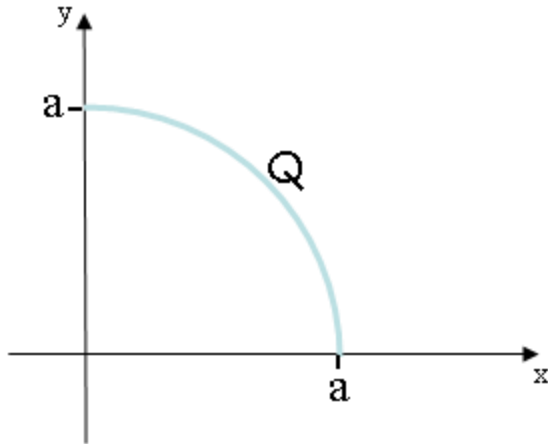
How would you change q_1 (keeping q_2 and q_3 fixed) in order to make the electric field at point P equal to zero?



Increase its magnitude and keep its sign the same

Since Q_1 is negative while Q_2 and Q_3 are both positive, it can cancel out their effects if it's strong enough. Since we saw the previous E field was positive in net, the negative charge has to be increased to bring this to zero.

Electric Field from Arc of Charge



A total charge $Q = -2.3 \mu\text{C}$ is distributed uniformly over a quarter circle arc of radius $a = 9.3 \text{ cm}$ as shown.

1)

What is λ the linear charge density along the arc?

C/m

Density is just

$$\frac{\text{Charge}}{\text{Length}}$$

Which in our case is:

$$\frac{Q}{\frac{\pi}{2}r}$$

Since the length of the arc is $\frac{1}{4}$ the circumference of a circle

2)

What is E_x , the value of the x-component of the electric field at the origin $(x,y) = (0,0)$?

N/C

We use our usual definition of the E field

$$\mathbf{E} = \frac{kQ}{r^2} \hat{r}$$

But we need to make it into an integral since we're not dealing with a point source

$$dE = \frac{k dQ}{r^2} = \frac{k \lambda ds}{r^2} = \frac{k \lambda r d\theta}{r^2}$$

To find the x component we use trigonometry

$$dE_x = \frac{k \lambda d\theta}{r} \cos\theta$$

Integrating from 0 to $\pi/2$ we get

$$E = \frac{k\lambda}{r} \left(\sin\left(\frac{\pi}{2}\right) - \sin(0) \right)$$

$$E = \frac{k\lambda}{r}$$

3)

What is E_y , the value of the y-component of the electric field at the origin $(x,y) = (0,0)$?

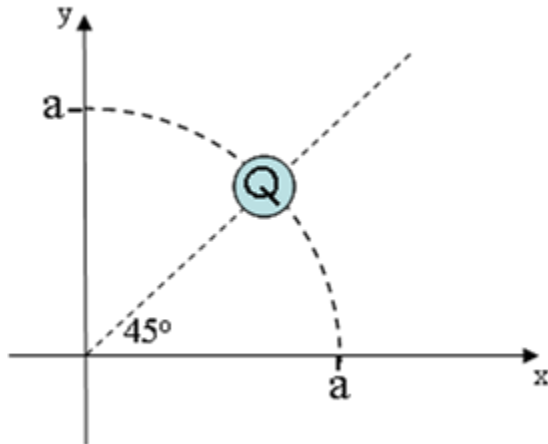
N/C

Since the arc is radially symmetric, integrating the y component

$$dE_y = \frac{k\lambda d\theta}{r} \sin\theta$$

From 0 to $\pi/2$ gives exactly the same as the x value

4)



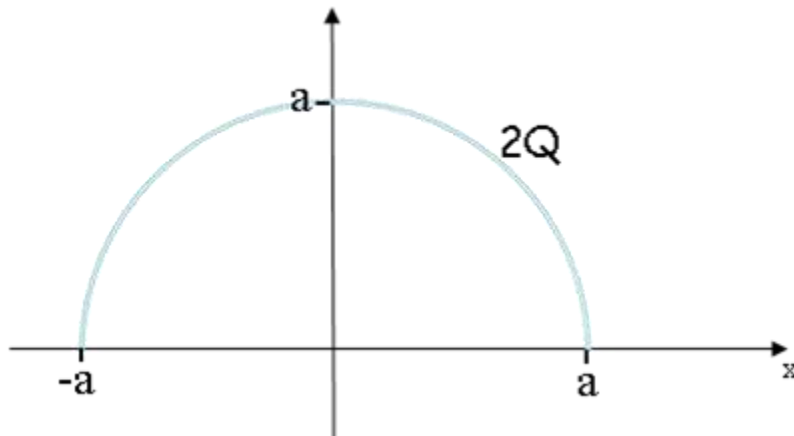
How does the magnitude of the electric field at the origin for the quarter-circle arc you have just calculated compare to the electric field at the origin produced by a point charge $Q = -2.3 \mu\text{C}$ located a distance $a = 9.3 \text{ cm}$ from the origin along a 45° line as shown in the figure?



The magnitude of the field from the point charge is greater than that from the quarter-arc of charge

While integrating the E field along the curve gives the same strength as the point charge, each of these small contributions is in a different direction so along the radial direction the electric field from the arc only has a smaller part that actually contributes

5)



What is the magnitude of the electric field at the origin produced by a semi-circular arc of charge $= -4.6 \mu\text{C}$, twice the charge of the quarter-circle arc?

3.04E6

N/C

Since the arc is symmetric about the y axis, the E_x fields from the two arcs cancel each other out. The Y contributions add to each other however and since a single side of the arc is the same object we've been considering in earlier problems, the net E field here is just the answer to (3) doubled.