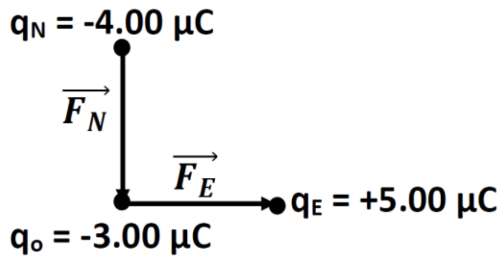
10. A charge of -3.00 μC is fixed at the center of a compass. Two additional charges are fixed on the circle of the compass, which has a radius of 0.100 m. The charges on the circle are -4.00 μC at the position due north and + 5.00 μC at the position due east. What are the magnitude and direction of the net electrostatic force acting on the charge at the center? Specify the direction relative to due east.



$$\overrightarrow{F_{Net}} = \overrightarrow{F_N} + \overrightarrow{F_E}$$

$$\overrightarrow{F_N} = k\frac{q_o q_N}{r_{oN}^2}\widehat{-N}\overrightarrow{F_N} = k\frac{q_o q_N}{r_{oN}^2}\widehat{S}$$

- sign due to same sign charges repel!

$$\overrightarrow{F_N} = k\frac{q_o q_N}{r_{oN}^2}\widehat{S} = \left(8.99\ x\ 10^9\ {Nm^2}/{C^2}\right)\frac{(3.00\ x\ 10^{-6}C)(4.00\ x\ 10^{-6}C)}{(0.100\ m)^2}\widehat{S}$$

$$\overrightarrow{F_N} = \left(8.99\ x\ 10^9\ {Nm^2}/{C^2}\right)\frac{1.20\ x\ 10^{-11}C^2}{0.0100\ m^2}\widehat{S} = 10.79\ N\ \widehat{S}$$

$$\overrightarrow{F_E} = k\frac{q_o q_E}{r_{oE}^2}\widehat{E}$$

No sign because opposite charges attract!

$$\overrightarrow{F_E} = k\frac{q_o q_E}{r_{oE}^2}\widehat{E} = \left(8.99\ x\ 10^9\ {Nm^2}/{C^2}\right)\frac{(3.00\ x\ 10^{-6}C)(5.00\ x\ 10^{-6}C)}{(0.100\ m)^2}\widehat{E}$$

$$\overrightarrow{F_E} = \left(8.99\ x\ 10^9\ {Nm^2}/{C^2}\right)\frac{1.50\ x\ 10^{-11}C^2}{0.0100\ m^2}\widehat{E} = 13.49\ N\ \widehat{E}$$

So

$$\overrightarrow{F_{Net}} = \overrightarrow{F_N} + \overrightarrow{F_E} = 10.79\ N\ \widehat{S} + 13.49\ N\ \widehat{E}$$

$\widehat{S}$ and $\widehat{E}$ are perpendicular vectors so use Pythagorean theorem to add.

$$\left|\overrightarrow{F_{Net}}\right| = \sqrt{\left|\overrightarrow{F_N}\right|^2 + \left|\overrightarrow{F_E}\right|^2} = \sqrt{(10.79\ N)^2 + (13.49\ N)^2} = \sqrt{298.40\ N^2} = 17.27\ N$$

Angle relative to East will be South of East

$$\theta = \tan^{-1}\left(\frac{F_S}{F_E}\right) = \tan^{-1}\left(\frac{10.79\ N}{13.49\ N}\right) = \tan^{-1}(0.7999) = 38.66°$$

$$\boxed{\overrightarrow{F_{Net}} = 17.3\ N\ @\ 38.7°\ \hat{S}\ of\ \hat{E}}$$

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Please send any comments or questions about this page to ddonovan@nmu.edu

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