Physics

Electrostatics: Coulomb’s Law – Force on a Third Charge

Science and Mathematics Education Research Group

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Force on a Third Charge
Three charges with equal magnitude but different signs are arranged as shown. $Q_3$ is the same distance away from $Q_1$ and $Q_2$. What is the direction of the net force on $Q_3$, if any?

A. No net force

B. $\vec{F}_{\text{net}}$

C. $\vec{F}_{\text{net}}$

D. $\vec{F}_{\text{net}}$

E. $\vec{F}_{\text{net}}$
Answer: B

Justification: $Q_1$ and $Q_3$ are both positive and will repel each other. $Q_1$ and $Q_3$ repel each other. This means that the force $Q_1$ exerts on $Q_3$ will point away from $Q_1$.

$Q_2$ and $Q_3$ have opposite charges, so they attract each other. $Q_2$ and $Q_1$ also attract each other. The force $Q_2$ exerts on $Q_3$ will point toward $Q_2$.

Adding the two forces gives $F_{\text{net}}$. 
Two charges with the same magnitude but different signs are arranged as shown. Where should a positive charge be placed so that it experiences no net force? B.

E. The charge will always experience a non-zero net force
Answer: E

Justification: In order for the third charge to experience zero net force, the force it experiences due to both $Q_1$ and $Q_2$ must have equal magnitudes but point in opposite directions. Only points equidistant from $Q_1$ and $Q_2$ (points along the dashed vertical line) will experience a force with equal magnitude from $Q_1$ and $Q_2$. However, from last question we know that the net force will point to the right (towards the negative charge) for any positive charge placed along the vertical line equidistant from both charges. Therefore a charge will always experience a non-zero force.
All of the charges are the same distance apart.

What is the direction of the force $Q_1$ exerts on $Q_3$?
Answer: E

Justification: The two charges $Q_1$ and $Q_3$ are opposite and will attract each other. $Q_1$ is pulling $Q_3$ closer. This means that the force $Q_1$ exerts on $Q_3$ will point from $Q_3$ towards $Q_1$.

Forces A and C are along the line between $Q_3$ and $Q_2$ and represent an interaction between those two charges. Force B is a repelling force between $Q_3$ and $Q_1$.

And Force D is the net force applied on charge $Q_3$.
Coulomb’s Law IV

What is the direction of the net force acting on Q₃?
A. up
B. down
C. to the left
D. to the right
Solution

Answer: B

Justification: $F_{\text{net}}$ is found by adding all of the vectors together.

Because of symmetry in the system, the x-components of $F_{1\text{on3}}$ and $F_{2\text{on3}}$ will cancel out, and $F_{\text{net}}$ will point down.
The central particle of charge $-2q$ is surrounded by a square array of charged particles. The square has side length $d$. What is the magnitude and direction of the net electrostatic force on the central particle due to the other particles?

A. $-7q$
B. $3q$
C. $-5q$
D. $4q$

D. There will be no net force
Solution

**Answer:** D

**Justification:** This problem can be solved with symmetry. Each charge along the edge of the square has an equal pair charge on the opposite side of the square. The forces caused by these two charges will cancel each other when they are added together, since they are equal in magnitude but opposite in direction.