a place of mind

FACULTY OF EDUCATION

Department of
Curriculum and Pedagogy

Physics
Electrostatics: Coulomb's Law – Force on a Third Charge

Science and Mathematics Education Research Group

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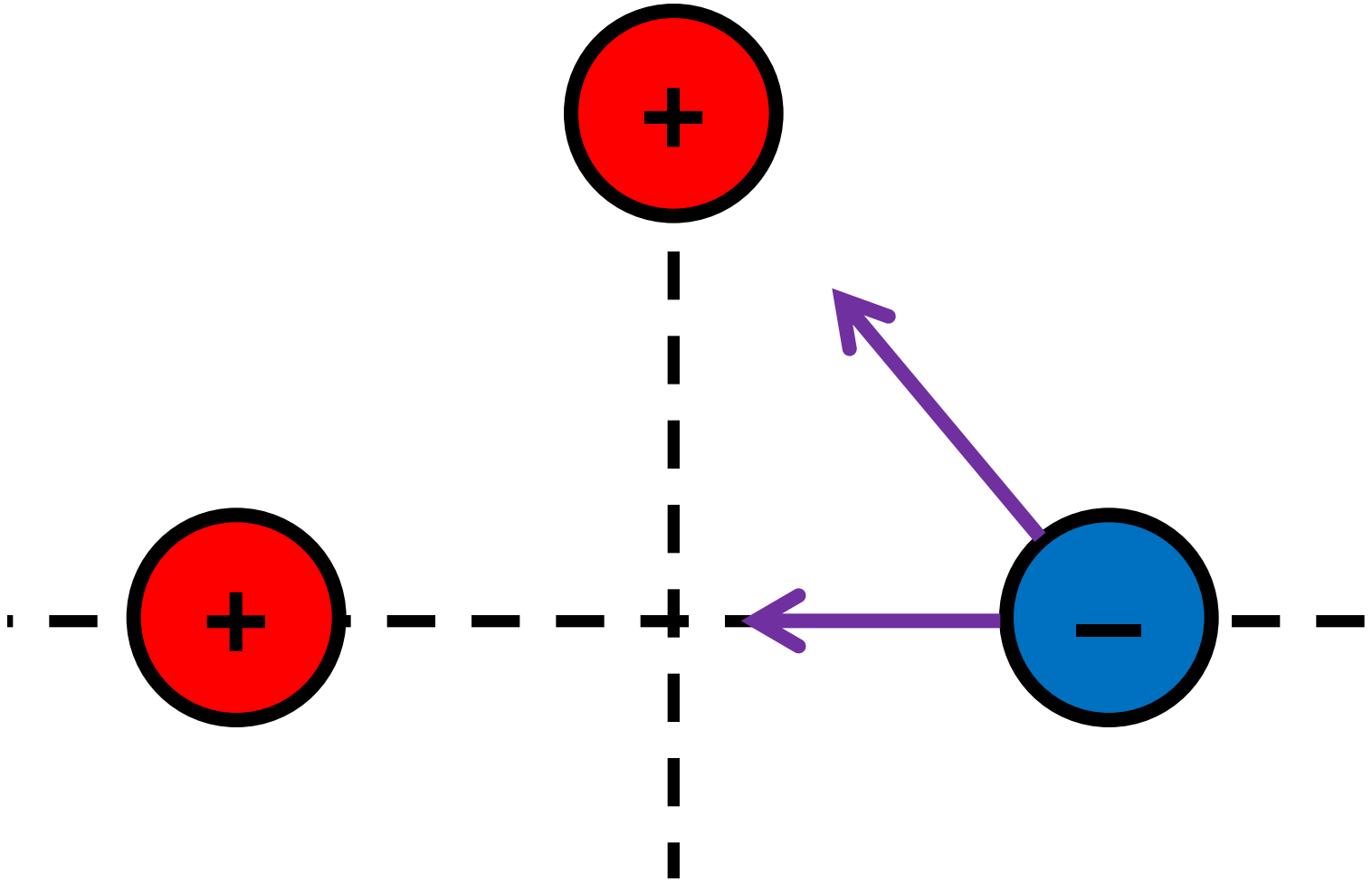
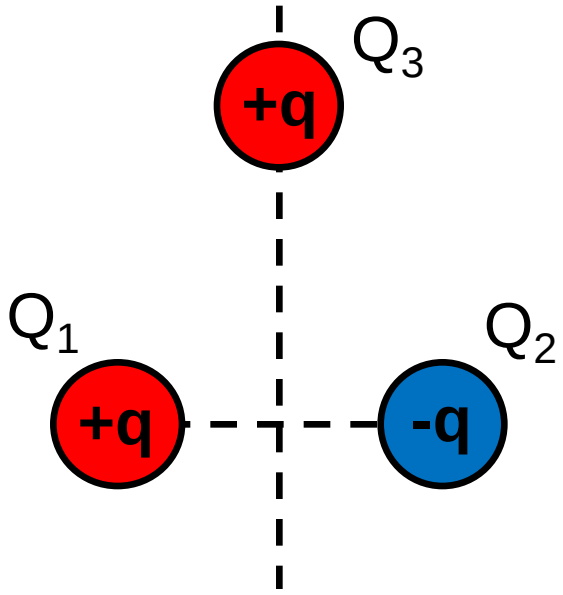
Force on a Third Charge



Coulomb's Law I

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. $\mathbf{F}_{net}$ →

C. $\mathbf{F}_{net}$ ←

D. $\mathbf{F}_{net}$ ↑

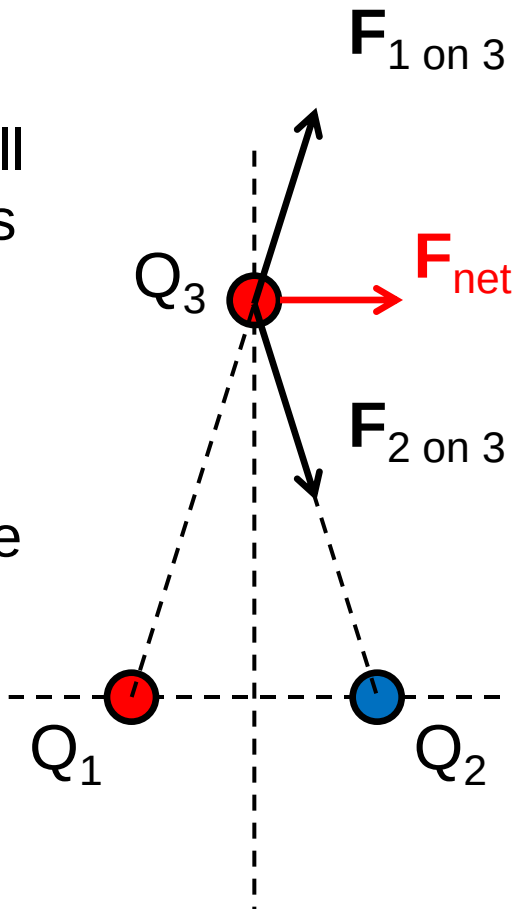
E. $\mathbf{F}_{net}$ ↓

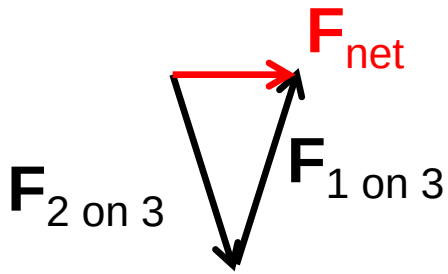
Solution

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.

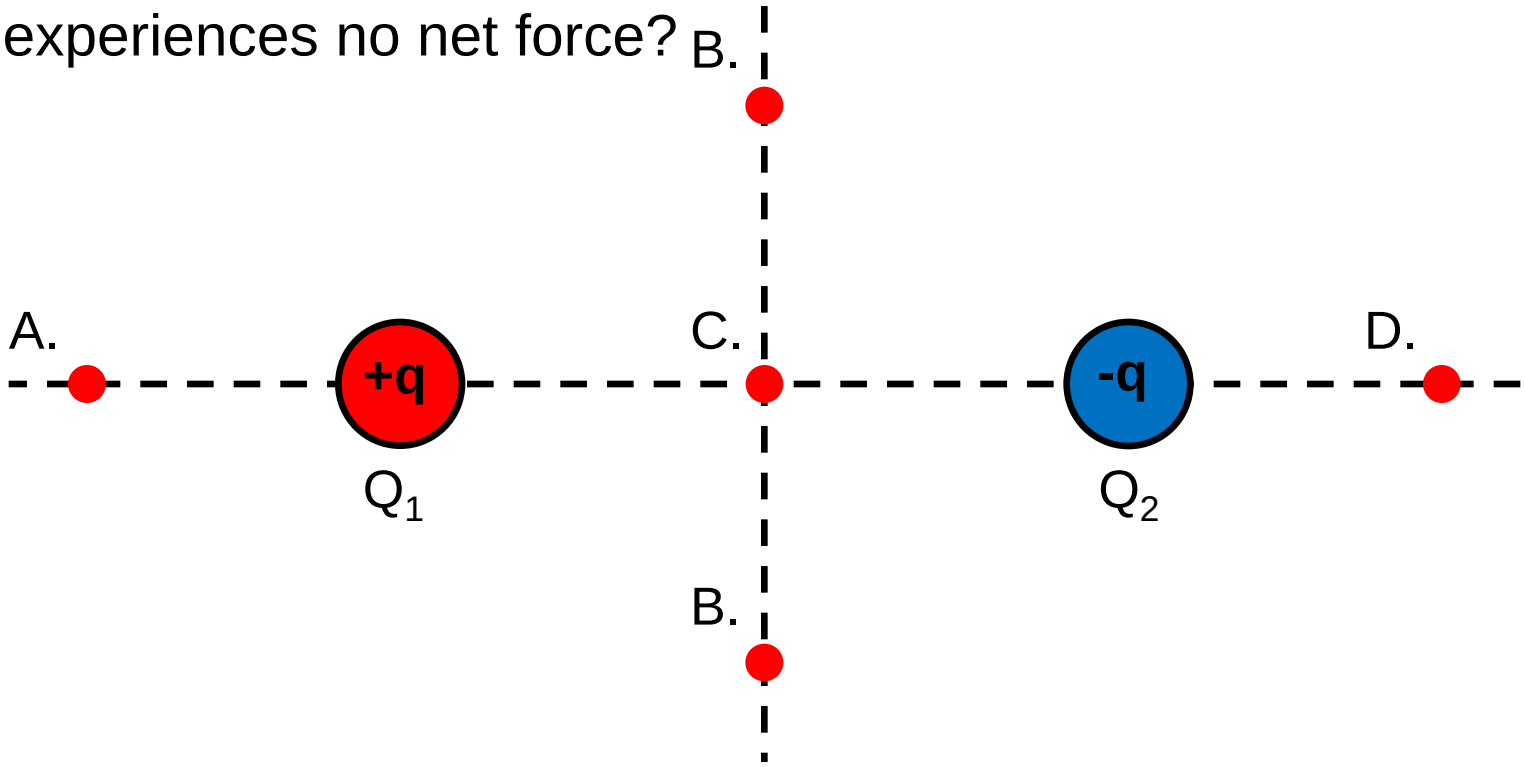




Adding the two forces gives F_{net}.

Coulomb's Law II

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?

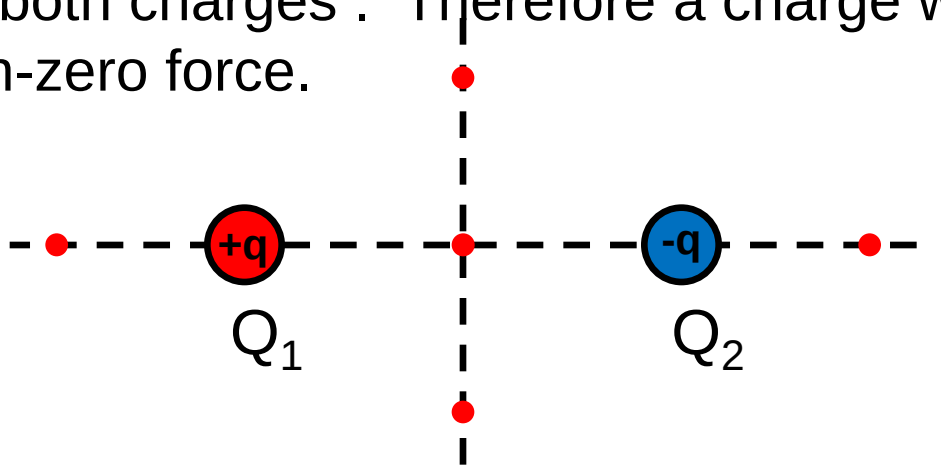


E. The charge will always experience a non-zero net force

Solution

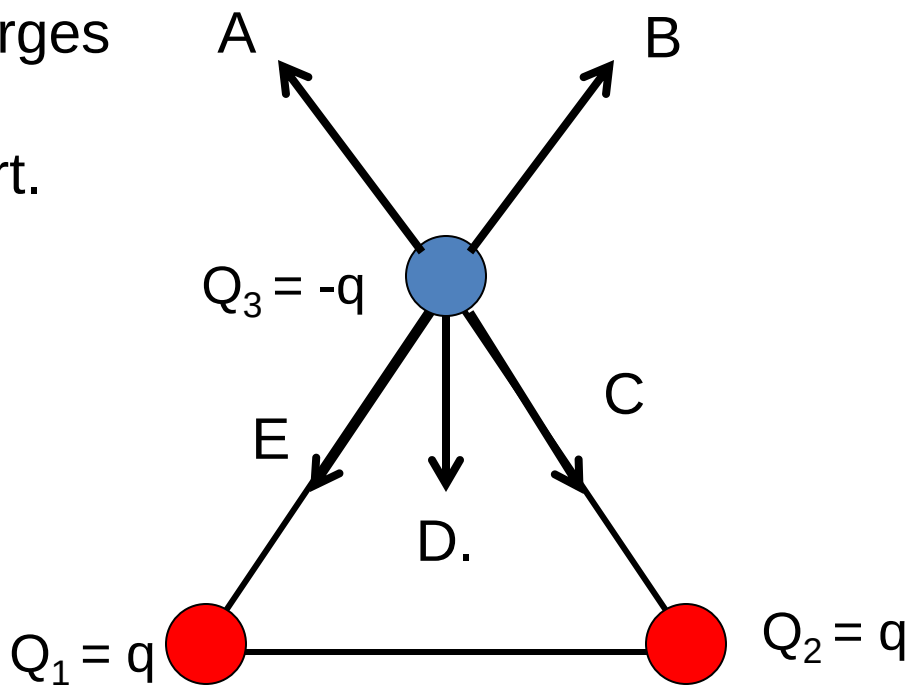
Answer: E

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.



Coulomb's Law III

All of the charges are the same distance apart.



What is the direction of the force Q_1 exerts on Q_3?

Solution

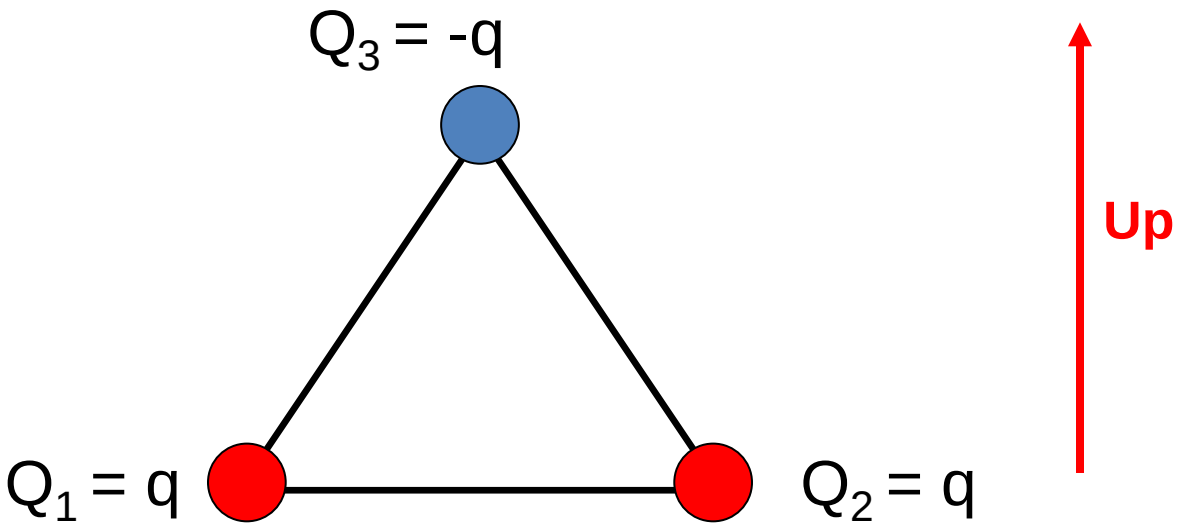
Answer: E

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 Q_3?

A. up

B. down

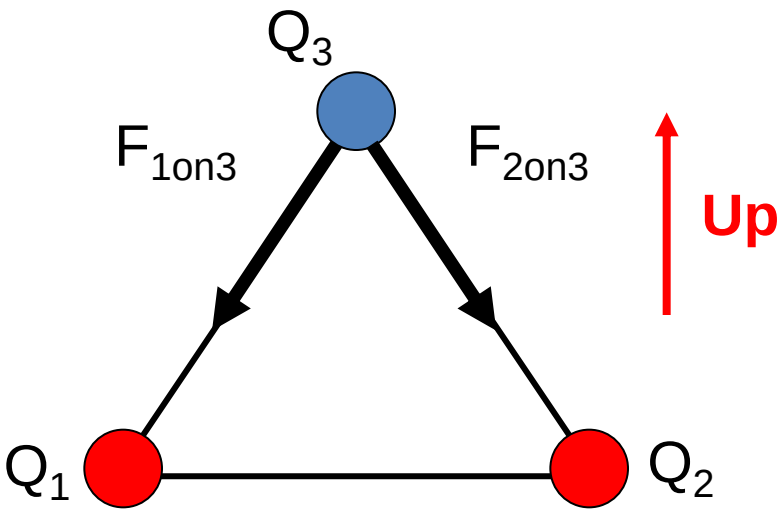
C. to the left

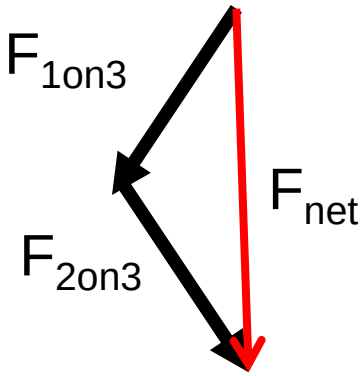
D. to the right

Solution

Answer: B

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

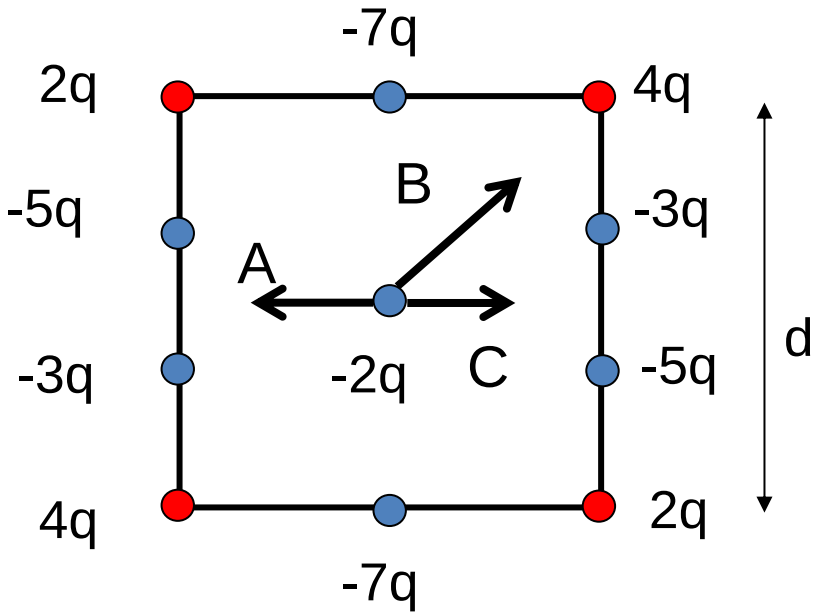




Because of symmetry in the system, the x-components of F_{1on3} and F_{2on3} will cancel out, and F_{net} will point down.

Coulomb's Law V

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?



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.