B3 · Net electric force

Student notes - follow the slides, fill the blanks, work the questions

Add force vectors on one target and choose between a charge model and force balance.

Name: _____ Date: _____

Slide 1 of 5 · One target, several sources

B2 found the force between two charges. Most real cases have more than two. This lesson adds the forces on one charge.

Pick one charge as the _____. Every other charge is a _____. Find the force on the target from _____. The sum of the separate forces is the _____.

Coulomb's law F = _____ gives the _____ only, with k = _____. The direction comes from the signs: _____ charges push apart, _____ charges pull together.

Draw an arrow for each force first. Choose east as _____. An arrow east counts as _____ and an arrow west counts as _____. Add the forces _____. The sign of the net force gives its direction.

The distance r always runs from the _____ to the _____. If the target is outside the pair of sources, measure a _____ for each source. Label every position in a sketch before you calculate.

Example. A is +4.0 µC at x = 0, the target B is +2.0 µC at x = 0.30 m, and C is +3.0 µC at x = 0.50 m. East is positive. What is the net force on B, with its direction?

Work:

Answer: _____

Try it. Same positions, but C is now −3.0 µC. A is +4.0 µC at x = 0, the target B is +2.0 µC at x = 0.30 m, and C is at x = 0.50 m. What is the net force on B, with its direction?

Work:

Answer: _____

Sketch (draw and label the diagram):

Slide 2 of 5 · Forces at right angles

Slide 1 had forces on one line. Now two forces meet at a right angle.

A coordinate pair such as (0.30 m, 0) means _____. East is the positive x direction and _____ is the positive y direction.

Find each force with Coulomb's law, and decide each direction from the signs. Draw both arrows _____. If the two forces are at _____, draw a right triangle with the arrows as its sides.

The net force is the _____: F = _____. The angle comes from tan θ = _____, so θ = _____.

A direction needs an angle and a _____, such as "36.9° north of west". If the forces are at 90°, the net force is bigger than _____ but smaller than their _____.

Example. The target (+2.0 μC) is at the origin (0, 0). A +3.0 μC charge is at (0.30 m, 0) and a −4.0 μC charge is at (0, 0.40 m). What is the net force on the target, with its direction?

Work:

Answer: _____

Try it. Same positions, but the charge at (0.30 m, 0) is −3.0 μC and the charge at (0, 0.40 m) is +4.0 μC. The target is still +2.0 μC. What is the net force on the target, with its direction?

Work:

Answer: _____

Sketch (draw and label the diagram):

Slide 3 of 5 · Method: how to find the net force on one charge

These are the steps you used on slides 1 and 2, in one place.

Step 1, _____: sketch the target and every source. Label each charge and each _____.

Step 2, _____: for each source, F = _____, using the _____ of the charges only. Step 3, _____: alike charges push the target _____; unlike charges pull it _____ the source.

Step 4, _____: write each force as an _____ and a _____. East and north are _____; west and south are _____. Step 5, _____: add all the x parts, then add all the _____.

Step 6, _____: size = _____; angle = _____. Name the direction from a _____, such as “north of west”.

Example. Use the six steps. The target (+2.0 µC) is at (0, 0). A +3.0 µC charge is at (0.30 m, 0) and a −4.0 µC charge is at (0, 0.40 m).

Work:

Answer: _____

Try it. Use the six steps. The target (+1.0 µC) is at (0, 0). A +2.0 µC charge is at (0.20 m, 0) and a +3.0 µC charge is at (0, 0.30 m). Find the net force, with its direction.

Work:

Answer: _____

Slide 4 of 5 · A force along a diagonal

On slide 2 each force lay along an axis. Now a force points along a slant.

A source at (0.30 m, 0.40 m) is 0.30 m east and 0.40 m north of a target at the origin. The straight-line distance is r = _____. The force acts along this _____.

Find the size first with Coulomb's law. Alike charges push the target _____ from the source and unlike charges pull it toward the source. The target is pushed away, so a source to the north-east pushes the target _____.

A _____ is one part of a force along one axis. The force triangle has the _____ as the distance triangle, so component = force × (_____ ÷ _____). Each component is _____ than the force.

To add several forces, make two sums: one for _____ and one for _____. East and north count as _____; west and south count as _____. Then use _____ for the size and tan θ for the angle.

Example. The target (+1.0 µC) is at the origin and a +5.0 µC source is at (0.30 m, 0.40 m). What is the force on the target, and what are its east-west and north-south parts, with directions?

Work:

Answer: _____

Try it. The +1.0 µC target is at the origin and the +5.0 µC source is at (0.30 m, 0.40 m). A second source of −2.0 µC is added at (0, 0.20 m). What is the net force on the target, with its direction?

Work:

Answer: _____

Sketch (draw and label the diagram):

Slide 5 of 5 · A charge hanging at rest

So far every force was electric. Now gravity and a thread pull as well.

Weight W = _____, with g = _____: each kilogram weighs 9.81 N. T is the _____, the pull of the thread. F_e is the _____, which is horizontal.

At rest the net force is _____. The three force arrows close into a _____. Draw the weight straight _____, the tension along the _____ and the electric force _____.

In the triangle, θ is the angle between the weight and the _____. F_e is _____ θ and mg is adjacent to θ: tan θ = _____, so F_e = _____.

The angle θ is measured from the _____. F_e is _____ the angle and mg is _____ to it, so use _____, not sine or cosine. For two equal charges, Coulomb's law then gives q = _____.

Example. A sphere of mass 0.0100 kg hangs from a thread at 20.0° from the vertical, pushed sideways by a fixed charge 0.15 m away. Find the electric force. If the two charges are equal, find each charge.

Work:

Answer: _____

Try it. A sphere of mass 0.0200 kg hangs from a thread and is pushed sideways by a fixed charge so that the thread makes 30.0° with the vertical. The sphere is at rest. What is the size of the electric force on the sphere? Use g = 9.81 m/s².

Work:

Answer: _____

Sketch (draw and label the diagram):

B3 · Practice

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Use $k = 8.99 \times 10^9$ N·m²/C² and $g = 9.81$ m/s² where needed. These values are from the Alberta Physics 30 data sheets, Constants section. All point-charge calculations approximate air as vacuum.

Easy · B3-P01. A is positive and left of a negative target B. C is negative and right of B. Draw the two force arrows on B. Do the forces add or partly cancel? Explain each arrow.

Work:

Final answer (with unit and sign): _____

Easy · B3-P02. The forces on one charge are 0.600 N right and 0.250 N left. Choose right as positive. What are the signed components and the net force?

Work:

Final answer (with unit and sign): _____

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Easy · B3-P03. A target feels 0.400 N east and 0.400 N west. What is its net force? Does that mean neither source exerts a force? Explain.

Work:

Final answer (with unit and sign): _____

Easy · B3-P04. A charged sphere is at rest with its string tilted from vertical by a horizontal electric force. Describe the weight, tension and electric-force arrows. Why must the tension not be drawn vertically?

Work:

Final answer (with unit and sign): _____

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Medium · B3-P05. Point charges in air are A = +3.00 μC at x = 0, target B = −1.00 μC at x = 0.300 m and C = +1.00 μC at x = 0.600 m. What is the net force on B? Use $k = 8.99 \times 10^9$ N·m²/C².

Optional start: Calculate two pair forces; do not add source charges first.

Work:

Final answer (with unit and sign): _____

Medium · B3-P06. The calculated electric forces on a target are 0.500 N east and 0.200 N north. Draw a vector triangle. What are the size of the net force and its angle north of east?

Work:

Final answer (with unit and sign): _____

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Medium · B3-P07. A 4.00×10^{-4} kg charged sphere hangs at rest. Its string is 25.0° from vertical and the electric force acts horizontally right. What are the electric-force magnitude and the tension? Use $g = 9.81$ m/s².

Optional start: The vertical component uses cosine because the angle is from vertical.

Work:

Final answer (with unit and sign): _____

Medium · B3-P08. Case A gives two point charges and their distance. Case B gives a hanging sphere’s mass and string angle from vertical, with a horizontal electric force. Choose a method to find electric force in each case. Explain why the other method cannot be used directly from the givens.

Work:

Final answer (with unit and sign): _____

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Challenging · B3-P09. Point charges in air are target P = +1.00 μC at (0,0), A = +2.00 μC at (−0.300 m,0), and C = +1.00 μC at (0,+0.300 m). What is the net electric force on P, as a magnitude and direction? Use $k = 8.99 \times 10^9$ N·m²/C².

Work:

Final answer (with unit and sign): _____

Challenging · B3-P10. A charged sphere hangs at rest in a horizontal electric force of 3.00×10^{-3} N. Its mass is 5.00×10^{-4} kg. What is the string's angle from vertical and what is the tension? Use g = 9.81 m/s².

Work:

Final answer (with unit and sign): _____

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Challenging · B3-P11. Two sources exert electric forces of 0.600 N east and 0.800 N north on a target. A student reports 1.40 N northeast. Find the correct magnitude and direction. Explain exactly what the student’s addition assumes incorrectly.

Work:

Final answer (with unit and sign): _____

Challenging · B3-P12. A = +2.00 μC is at x = 0 and C = +8.00 μC is at x = 0.900 m. A positive target charge is placed somewhere between them. Where is the net electric force zero? Give its distance from A and explain why the target’s charge magnitude is not needed.

Work:

Final answer (with unit and sign): _____