B4 · Electric fields

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

Distinguish field from force, map field directions and combine source fields.

Name: _____ Date: _____

Slide 1 of 6 · Field means force per charge

In B2 and B3, one charge pushed another across empty space. A field explains how.

A charge can push another charge across empty space. It does this with a _____. A small test charge, _____, feels a force F. Double q_test and F _____.

So divide out the charge: E = _____, the force per unit charge, in _____.

E points the way a _____ test charge is pushed. A negative charge is pushed the _____ way.

F = _____. The size of q gives the size of F. The _____ gives the direction.

Convert μC to _____: multiply by _____. Keep extra digits and round _____, at the end.

Example. A +5.00 μC test charge feels a force of 0.0150 N south at a point. What are the size and direction of the electric field at the point?

Work:

Answer: _____

Try it. An electron ($e = 1.60 \times 10^{-19}$ C) is placed at a point where the electric field is 500 N/C north. What are the size and direction of the force on the electron?

Work:

Answer: _____

Slide 2 of 6 · The field of a point charge

Slide 1 defined the field. Now find it for a point charge.

A point source _____ makes a field. r is the distance from the _____. Coulomb's law gives $F = k|Q|q_{test}/r^2$. Divide by q_{test} and it _____.

E = _____, with k = _____.

The field depends on the _____ and the _____, not on the test charge. Double r: the field is _____.

Positive source: the field points _____. Negative source: _____. Use $|Q|$ in the formula. The sign gives _____ only.

Convert prefixes first: μ = _____, n = _____. The distance must be in _____.

Example. A source of +4.0 μC is 0.30 m from point P. Use $k = 8.99 \times 10^9$ N·m²/C². What are the size and direction of the electric field at P?

Work:

Answer: _____

Try it. A source of −2.0 nC (that is, -2.0×10^{-9} C) is 0.050 m from point P. What are the size and direction of the electric field at P?

Work:

Answer: _____

Slide 3 of 6 · From field to force to acceleration

Slides 1 and 2 gave the field. Now use it to find how a particle moves.

Field gives _____, and force gives _____. Here q is the particle's _____ charge, not the test charge.

Force: F = _____. Only the electric force acts, so this is the net force.

Acceleration: a = _____, so a = _____. Do the force on its own line first.

The force points _____ the field for a positive charge and _____ it for a negative charge. A uniform field has the _____ everywhere.

An electron has mass _____. Its weight is about 10^{13} times smaller than this force, so gravity is _____.

Example. An electron ($q = -1.60 \times 10^{-19}$ C, $m = 9.11 \times 10^{-31}$ kg) is placed in a uniform electric field of 2.50×10^{3} N/C north. Only the electric force acts. What are the size and direction of the electron's acceleration?

Work:

Answer: _____

Try it. A proton ($q = +1.60 \times 10^{-19}$ C, $m = 1.67 \times 10^{-27}$ kg) is placed in a uniform electric field of 2.50×10^{3} N/C north. Only the electric force acts. What are the size and direction of the proton's acceleration?

Work:

Answer: _____

Slide 4 of 6 · Method: how to go from field to force to acceleration

These are the steps you used on slide 3.

Step 1: _____ the field E. Use the given field, or E = _____ for a point source, with the size of Q.

Step 2: name the _____ of E: away from a _____ source and toward a _____ source.

Step 3: find the force with F = _____. Here q is the charge placed in the field, not the test charge. Use its _____.

Step 4: name the direction of F: the _____ E if q is positive and _____ E if q is negative.

Step 5: find the acceleration with a = _____, in the direction of _____.

Check: the answer has units of _____ and its direction matches the _____ of q.

Example. An electron ($q = -1.60 \times 10^{-19}$ C, $m = 9.11 \times 10^{-31}$ kg) is placed in a uniform electric field of 2.50×10^{3} N/C north. Only the electric force acts. What are the size and direction of the electron's acceleration?

Work:

Answer: _____

Try it. A source of +3.0 µC makes the field at a point 0.30 m away. A −2.0 µC charge of mass 0.0040 kg is placed there. What are the size and direction of its acceleration? Only the electric force acts.

Work:

Answer: _____

Slide 5 of 6 · Adding fields from several sources

So far one source made the field. Now there are two.

Two sources make two fields. Add them as _____. The sum is the _____.

Find each field with E = _____. Mark each direction at the point. Then add. On a line, call one direction _____.

Arrows the same way: the sizes _____. Opposite ways: the sizes _____. At right angles: size = _____, tan θ = _____.

Field lines: 1. draw the charges and mark their _____; 2. start on a _____ charge, end on a _____ one; 3. put lines _____ where the field is strong; 4. add an _____ on every line.

Lines never _____. Between large parallel plates the lines are straight and _____: a _____ field.

Example. Two sources, +2.0 μC at x = 0 and −2.0 μC at x = 0.40 m. Point P is midway between them, 0.20 m from each. Draw the field arrows at P, then find the size and direction of the net field at P.

Work:

Answer: _____

Try it. Two equal positive point charges are placed on a horizontal line, and point P is midway between them. Which statement about the field at P is correct? A. It is zero. B. It is directed toward the left charge. C. It is directed toward the right charge. D. It is twice the field of one charge.

Work:

Answer: _____

Sketch (draw and label the diagram):

Slide 6 of 6 · Method: how to add fields from several sources

These are the steps you used on slide 5.

Step 1: _____ the point and every source, with each source's sign and its distance from the point.

Step 2: find the size of each field on its own with E = _____.

Step 3: draw each arrow starting at the point, _____ a positive source and _____ a negative source.

Step 4: _____ each arrow into x and y parts. Choose a positive direction for each axis and give each part a + or − sign.

Step 5: add all the _____ parts to get Ex and all the _____ parts to get Ey.

Step 6: E = _____. Name the direction from a _____, such as east.

Check: the net arrow on the drawing points the _____ as your answer.

Example. Two sources, +2.0 µC at x = 0 and −2.0 µC at x = 0.40 m. Point P is midway between them, 0.20 m from each. East is positive. Find the size and direction of the net field at P.

Work:

Answer: _____

Try it. Two sources, +4.0 µC at x = 0 and +1.0 µC at x = 0.60 m. East is positive. Point P is 0.20 m from the +4.0 µC source, on the line between the sources. Find the size and direction of the net field at P.

Work:

Answer: _____

B4 · Practice

Electric fields | Questions 1-2 of 12

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 · B4-P01. A fixed source creates a field at P. A small positive test charge q_test is replaced by a test charge +2q_test and the source does not change. What happens to the field at P and to the force on the test charge? Explain using the definition of field.

Work:

Final answer (with unit and sign): _____

Easy · B4-P02. A point source is positive. At a point to its left, draw the electric-field arrow. Then draw the force arrow on a negative test charge placed there. Explain both directions.

Work:

Final answer (with unit and sign): _____

B4 · Practice

Electric fields | Questions 3-4 of 12

Easy · B4-P03. A +4.00 µC test charge feels 0.0800 N east in an electric field. What is the field strength and direction at that point?

Work:

Final answer (with unit and sign): _____

Easy · B4-P04. Between large horizontal plates the electric field points up. Ignore the edges of the plates. Which plate is positive, which is negative, and which way is the electric force on an electron? Does the field strength change between two points inside?

Work:

Final answer (with unit and sign): _____

B4 · Practice

Electric fields | Questions 5-6 of 12

Medium · B4-P05. A point source $Q = -4.00\ \mu C$ is fixed in air. P is 0.200 m to its right. What is the electric field at P? Use $k = 8.99 \times 10^9\ N \cdot m^2/C^2$.

Work:

Final answer (with unit and sign): _____

Medium · B4-P06. A charge $q = -3.00\ nC$ is placed in a field of $4.00 \times 10^4\ N/C$ west. What is the electric force on it? Does its negative sign reverse the field itself?

Optional start: Separate the magnitude calculation from the negative-charge direction.

Work:

Final answer (with unit and sign): _____

B4 · Practice

Electric fields | Questions 7-8 of 12

Medium · B4-P07. At P, a +2.00 μC source is 0.300 m to the left and a −1.00 μC source is 0.300 m to the right. What is the net electric field at P? Use $k = 8.99 \times 10^9$ N·m²/C².

Work:

Final answer (with unit and sign): _____

Medium · B4-P08. A source is at (0,0). A field map shows E at (0.200 m,0) pointing right with strength 4.00×10^5 N/C. The source stays fixed. What is its sign? Predict the field magnitude and direction at (0.400 m,0) and at (−0.200 m,0).

Work:

Final answer (with unit and sign): _____

B4 · Practice

Electric fields | Questions 9-10 of 12

Challenging · B4-P09. Point sources A = +1.00 µC at (−0.300 m,0) and C = −2.00 µC at (0,+0.300 m) create a field at P = (0,0). What are the net field magnitude and direction? Use $k = 8.99 \times 10^9$ N·m²/C².

Work:

Final answer (with unit and sign): _____

Challenging · B4-P10. A point has an electric field of 6.00×10^4 N/C east. A small unknown charge feels 0.120 N west. What are the charge's magnitude and sign? Explain how the directions determine the sign.

Work:

Final answer (with unit and sign): _____

B4 · Practice

Electric fields | Questions 11-12 of 12

Challenging · B4-P11. Two equal sources are fixed on a horizontal line. Compare the field at the midpoint for (a) two positive sources and (b) a positive source on the left and an equal negative source on the right. Then describe field-line sketches for both pairs: add arrows and explain whether lines cross.

Work:

Final answer (with unit and sign): _____

Challenging · B4-P12. Mixed review: two identical metal spheres on insulating stands start with +6.00 µC and −2.00 µC, touch, then separate far apart. Afterwards one sphere is held fixed as a point source; the other is moved far enough away that its field at P is too small to matter. P is 0.300 m right of the fixed sphere. What field is at P, and what force acts on a −2.00 nC charge there? Use $k = 8.99 \times 10^9$ N·m²/C².

Work:

Final answer (with unit and sign): _____