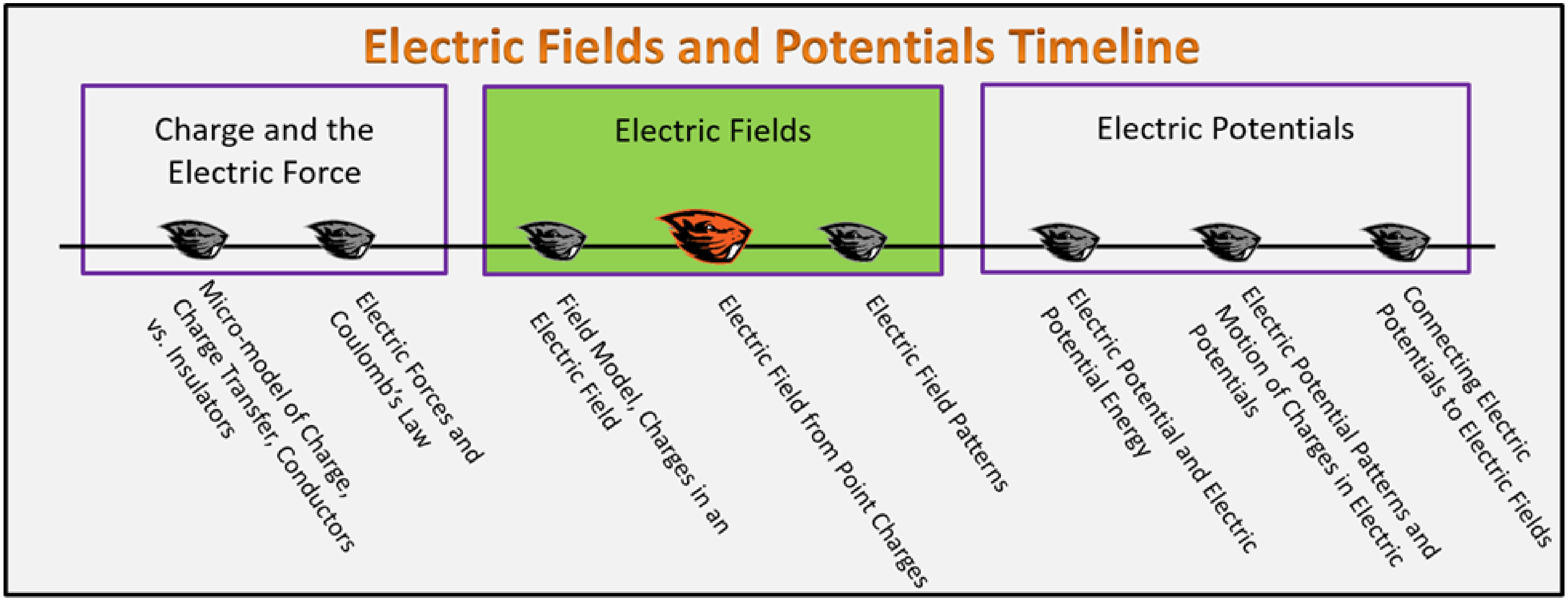
(EF.L2.123) Template for Boxsand

Friday, April 24, 2020 8:52 PM

Electric Fields
Familiarize Stage (EF.L2.1)

Pre-Lecture 2
Electric Field from Point Charges



Familiarization Stage: Electric Fields

Pre-lecture 2: Electric Field from Point Charges

Reading

1. Read

Lecture Videos

1. Watch

Example Problems

1. Watch

Simulations

1. Sim

Other Suggested Content

1. Check out

Practice

1. Try

Homework

EF.L2.1-01

Description: familiarization with electrical fields from point charges

Learning Objectives: [x,xx,…] Put the learning objective numbers here

Problem Statement: True or False: The electric-field lines from a negative point charge spread out radially and point outward.

EF.L2.1-02

Description: familiarization with electrical fields

Learning Objectives: [x,xx,...] Put the learning objective numbers here

Problem Statement: If five electric-field lines come out of point charge q_1 and 10 electric-field lines go into point charge q_2, what is the ratio q_1/q_2?

(1) –2
(2) 2
(3) –1
(4) 1
(5) −1/2
(6) 1/2
(4) 0

EF.L2.1-03

Description: Which charge creates the field and which feels it

Learning Objectives: [x,xx,...] Put the learning objective numbers here

Problem Statement: Rather than use Coulomb's Law to determine the force between two charges we prefer to use a field model approach. In the field model approach, which of the following statements are true?

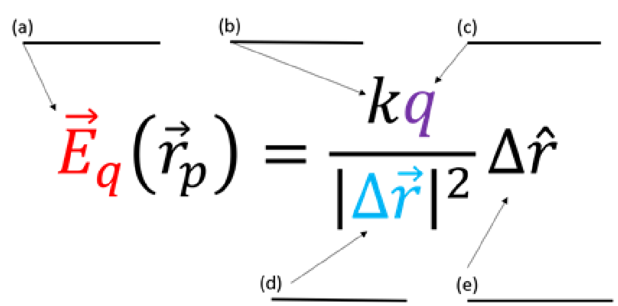
(1) The field from charge A exerts a force on charge A while the field from charge B exerts a force on charge B.
(2) The field from charge A exerts a force on charge B while the field from charge B exerts a force on charge A.

(3) The net field from charge A and B exerts a force on charge A and B separately.
(4) A charge will never directly feel a force from the field it creates.

EF.L2.1-04

Description: infographic quiz electric field point charge - label matching

Learning Objectives: [x,xx,...] Put the learning objective numbers here



Problem Statement: Consider the equation for the electric field from a point charge.
(a) Match each term with the correct description from the following list. (1) Coulomb's constant, (2) Unit vector, (3) Change in position, (4) Electric field from, (5) Charge

(b) Which of the following statements are true regarding this equation?

(1) q is the magnitude of the point charge.
(2) q can be either positive or negative.
(3) k is a positive constant.
(4) $\lvert \Delta \vec{r} \rvert^2$ is the magnitude of the displacement vector squared.
(5) $\lvert \Delta \vec{r} \rvert^2$ can be positive or negative.
(6) $\lvert \Delta \vec{r} \rvert^2$ is a vector
(7) $\vec{E}$ is a vector and gets its direction from a combination of $\Delta \hat{r}$ and the sign of q.

(c) Considering the unit vector "delta r hat" $\Delta \hat{r}$. Which of the following statements are true regarding this vector.

(1) It points in the direction of the displacement between a change and a location we wish to find the electric field.
(2) It has a magnitude of 1.
(3) It carries no units
(4) The x-component of it can be found by finding the x-component of $\Delta \vec{r}$ and then dividing by the magnitide of $\Delta \vec{r}$.
(5) It is the vector part of the of the electric field from a point charge equation, assigning direction (along with the sign of the charge q).

EF.L2.1-05

Description: Proportional reasoning around Coulomb's Law

Learning Objectives: [x,xx,...] Put the learning objective numbers here

Problem Statement: A small spherical object has a net charge **q** and generates an electric field **E**, at distance **r** away from a particular location. If the charge on the object quadruples and it moves 3.5 times farther away from that particular location, by what factor does the electric field change?

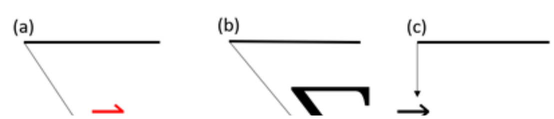
(1) 4/7
(2) 7/2
(3) 16/49
(4) 7/16
(5) 49/2

EF.L2.1-06

Description: infographic quiz net electric field - label matching

Learning Objectives: [x,xx,...] Put the learning objective numbers here

Problem Statement: Match each term with the correct description from the following list. (1) Electric field vectors, (2) Net electric field, 3) Summation

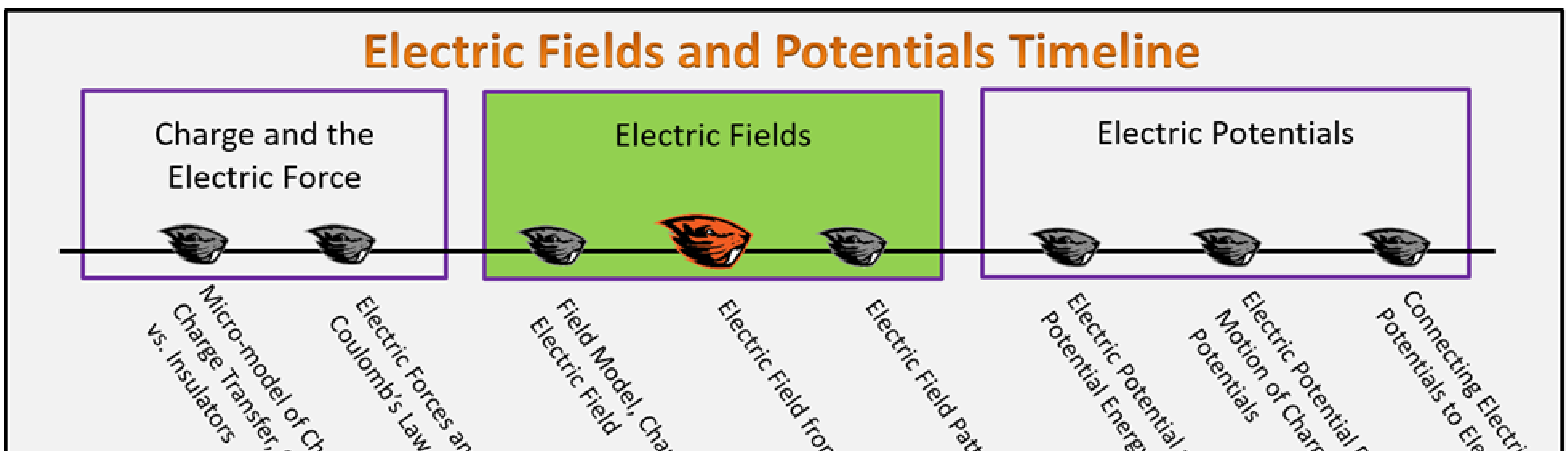


$$\vec{E}_{net} = \sum \vec{E}_i$$

Electric Fields

Foundation Stage (EF.L2.2)

Lecture 2
Electric Field from Point Charges



Textbook Chapters (* Calculus version)

- **BoxSand** :: KC videos (Electric Fields)
- **Knight** (College Physics : A strategic approach 3rd) :: 20.4 ; 20.5
- ***Knight** (Physics for Scientists and Engineers 4th) :: 23.2
- **Giancoli** (Physics Principles with Applications 7th) :: 16-7

Warm up

EF.L2.2-01:

Description: Conceptual question about addition of electric fields.

Learning Objectives: [?] - Can you identify the objectives from the previous lecture, and this lecture, that this question is relevant to?

Problem Statement: A point charge $\mathbf{q_1}$ creates an electric field $\vec{\mathbf{E}}_{1p}$ at a location **P** in space. Suddenly 2 more charges, $\mathbf{q_2}$ and $\mathbf{q_3}$ are brought into existence, both of which also create an electric field at location **P**. What is the total electric field at location **P**?

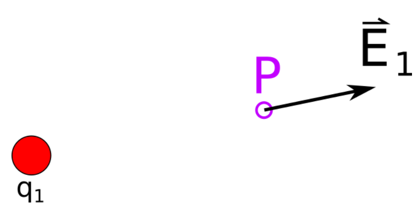
(1) $\vec{\mathbf{E}}_{1p}$

(2) $\vec{\mathbf{E}}_{1p} + \left(\vec{\mathbf{E}}_{2p}\right)\left(\vec{\mathbf{E}}_{3p}\right)$

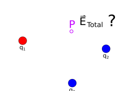
(3) $\vec{\mathbf{E}}_{1p} + \vec{\mathbf{E}}_{2p} + \vec{\mathbf{E}}_{3p}$

(4) $\vec{\mathbf{E}}_{1p} - \vec{\mathbf{E}}_{2p} - \vec{\mathbf{E}}_{3p}$

Initial



Final



Selected Learning Objectives

1. Coming soon to a lecture template near you.

Key Terms

- Unit vector
- Charge distribution
- Continuous charge distribution

Key Equations

Key Concepts

- Coming soon to a lecture template near you.

Questions

Act I: Electric Field from a Point Charge

EF.L2.2-02:

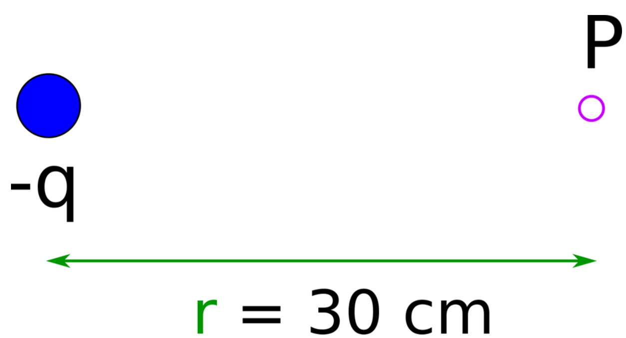
Description: Scaffolded question calculating the electric field from a single point charge. (1 minute + 2 minutes + 1 minute + 2 minutes + 1 minute + 4 minutes + 4 minutes + 3 minutes + 3 minutes + 2 minutes)

Learning Objectives: [?]

Problem Statement: Consider a negative charge $\mathbf{q_1}$ = - 3 x 10^{-6} C that exists in a space far away from other charges. We eventually wish to find the electric field created by $\mathbf{q_1}$. at some point **P** in space which is 30 cm to the right of the point charge.

(a) Where would be the wisest place to put an origin?

(1) Directly on the charge.
(2) At the point **P** in space we wish to find the field at.
(3) Halfway between the charge and point **P**.
(4) In a different universe where no charges exit.



(b) Using the origin chosen in part (a), what is the position vector to the charge, $\vec{\mathbf{r}}_q$?

(1) < 0 , 0 , 0 > cm
(2) < -30 , 0 , 0 > cm
(3) < -15 , 0 , 0 > cm

(c) Using the origin chosen in part (a), what is the position vector to the location of interest at point **P**, $\vec{\mathbf{r}}_p$?

(1) < 0 , 0 , 0 > cm
(2) < 30 , 0 , 0 > cm
(3) < 15 , 0 , 0 > cm

(4) < 0 , 30 , 0 > cm

(4) < 0 , 30 , 0 > cm

(d) What is the change in position from the charge $\mathbf{q_1}$ to the location of interest **P**, $\Delta\vec{\mathbf{r}}_{qp}$?

(1) < 0 , 0 , 0 > cm
(2) < 30 , 0 , 0 > cm
(3) < 15 , 0 , 0 > cm
(4) < -30 , 0 , 0 > cm

(e) What is the magnitude of the change in position from the charge $\mathbf{q_1}$ to the location of interest **P**, $\left|\Delta\vec{\mathbf{r}}_{qp}\right|$?

(1) 0 cm
(2) 30 cm
(3) 15 cm
(4) -30 cm

(f) Consider a negative charge $\mathbf{q_1} = -3 \times 10^{-6}$ C that exists in a space far away from other charges. The electric field from a point particle is given by , $\vec{\mathbf{E}} = \dfrac{\mathbf{k\ q}}{\left|\Delta\vec{r}_{qp}\right|^2}\ \Delta\ \hat{\mathbf{r}}_{qp}$.

What is the value of the stuff in front of the unit displacement vector? ($\mathbf{k} \approx 9.00 \times 10^9$ N m^2/C^2)

(1) 30 N/C
(2) - 30 N/C
(3) 900 N/C
(4) - 900 N/C
(5) 300,000 N/C
(6) -300,000 N/C

(g) Which of the following represents the unit displacement vector , $\Delta\hat{\mathbf{r}}_{qp}$?

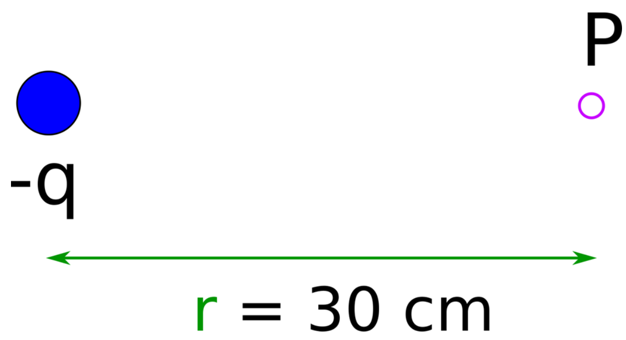
(1) < 0 , 0 , 0 >
(2) < 1 , 0 , 0 >
(3) < -1 , 0 , 0 >
(4) < 30 , 0 , 0 > cm

(h) Consider a negative charge $\mathbf{q_1}$ = - 3 x 10^{-6} C that exists in a space far away from other charges. Calculate the electric field created by $\mathbf{q_1}$. at some point **P** in space which is 30 cm to the right of the point charge.

(1) < -300,000 , 0 , 0 > N/C
(2) < 300,000 , 0 , 0 > N/C
(3) < -30 , 0 , 0 > N/C
(4) < 30 , 0 , 0 > N/C

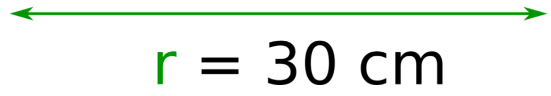
(i) A positive charge $\mathbf{q_o}$ = 2 x 10^{-6} C is placed at point **P** which is 30 cm to the right of a point charge of $\mathbf{q_1}$ = -3 x 10^{-6} C. What is the electric force on $\mathbf{q_o}$ from the field created by $\mathbf{q_1}$?

(1) < -6 , 0 , 0 > N
(2) < 6 , 0 , 0 > N
(3) < -0.6 , 0 , 0 > N
(4) < 0.6 , 0 , 0 > N



(i) In part **(g)** we found the electric field at a location 30 cm to the right of a charge $\mathbf{q_1}$ = -3 x 10^{-6} C. Which of the following would be the electric field at the same location if the charge $\mathbf{q_1}$ were positive instead of negative?

(1) < -300,000 , 0 , 0 > N/C
(2) < 300,000 , 0 , 0 > N/C
(3) < -30 , 0 , 0 > N/C
(4) < 30 , 0 , 0 > N/C



Act II: Electric Field from Multiple Point Charges

EF.L2.2-03:

Description: Calculate electric field from 4 point charges with symmetry. (4 minutes)

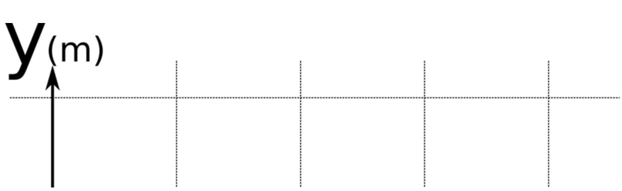
Learning Objectives: [?]

Problem Statement: Four charges, all of which are **q** = - 2**e** are placed at the following coordinates:

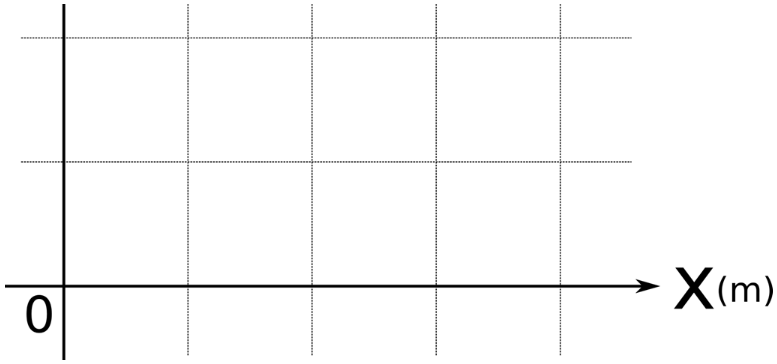
< 3 , 2 , 0 > m	< 1 , 2 , 0 > m	< 1 , 0 , 0 > m	< 3 , 0 , 0 > m

What is the electric field at the location < 2, 1, 0 > m ?

(1) < 0 , 0 , 0 > N/C
(2) < $1/\sqrt{2}$, $1/\sqrt{2}$, 0 > N/C



(3) < $-1/\sqrt{2}$, $-1/\sqrt{2}$, 0 > N/C
(4) < $-1/\sqrt{2}$, $1/\sqrt{2}$, 0 > N/C
(5) < $1/\sqrt{2}$, $-1/\sqrt{2}$, 0 > N/C



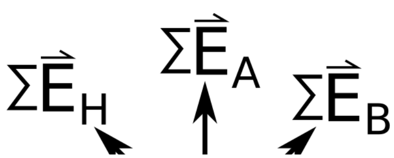
EF.L2.2-04:

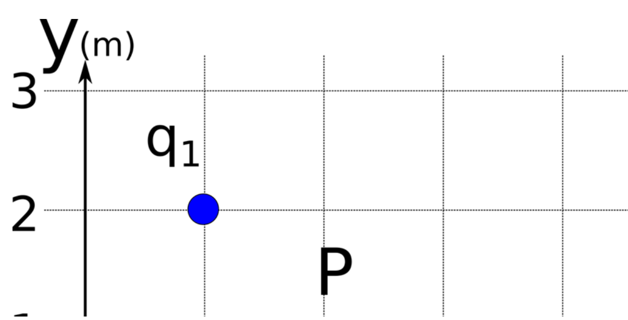
Description: Scaffolded question calculating the electric field from three point charges with symmetry. (4 minutes + 1 minute + 2 minutes + 1 minute + 2 minutes + 1 minute + 4 minutes + 4 minutes + 3 minutes + 3 minutes + 2 minutes)

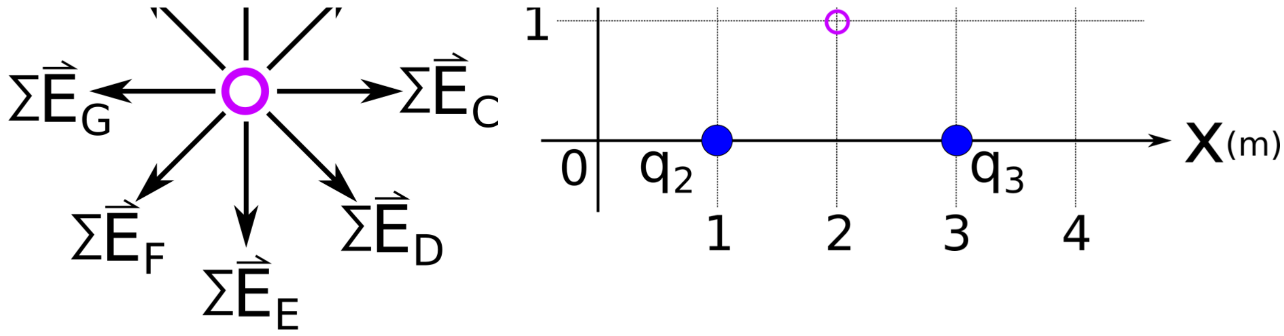
Learning Objectives: [?]

Problem Statement: Consider the charge distribution with 3 point charges shown in the figure below. All charges have charge **q** = -**e**.

(a) Which of the following vectors best represents the net electric field at location P?







(b) Using the origin given in the figure, what is the position vector to the charge 2, $\vec{\mathbf{r}}_2$?

(1) < 0 , 0 , 0 > m
(2) < 1 , 0 , 0 > m
(3) < -1 , 0 , 0 > m
(4) < 0 , 1 , 0 > m

(c) Using the origin given in the figure, what is the position vector to the location of interest at point **P**, $\vec{\mathbf{r}}_p$?

(1) < 2 , 0 , 0 > m
(2) < 2 , 1 , 0 > m
(3) < 2 , 2 , 0 > m
(4) < 1 , 1 , 0 > m

(d) What is the change in position from the charge $\mathbf{q_2}$ to the location of interest **P**, $\Delta\vec{\mathbf{r}}_{2p}$?

(1) < 1 , 1 , 0 > m
(2) < -1 , 1 , 0 > m
(3) < -1 , -1 , 0 > m
(4) < 0 , 1 , 0 > m

(e) What is the magnitude of the change in position from the charge $\mathbf{q_2}$ to the location of interest **P**, $|\Delta\vec{\mathbf{r}}_{2p}|$?

(1) 1 m
(2) 2 m
(3) $\sqrt{2}$ m
(4) -2 m

(f) Consider the charge distribution with 3 point charges shown in the figure below. All charges have charge **q** = -**e**. The electric field from a point particle is given by ,

$\vec{\mathbf{E}} = \dfrac{\mathbf{k\,q}}{|\Delta \vec{r}_{qp}|^2}\;\Delta\,\hat{\mathbf{r}}_{qp}$. What is the value of the stuff in front of the unit displacement vector for the electric field contribution from $\mathbf{q_2}$?

(1) $\dfrac{\mathbf{k\,e}}{2}\,\dfrac{1}{m^2}$

(2) $\dfrac{\mathbf{k\,e}^2}{2}\,\dfrac{1}{m}$

(3) $\dfrac{-\mathbf{k\,e}}{2}\,\dfrac{1}{m^2}$

(4) $\dfrac{-\mathbf{k\,e}}{\sqrt{2}}\,\dfrac{1}{m^2}$

(5) $\dfrac{\mathbf{k\,e}}{\sqrt{2}}\,\dfrac{1}{m}$

(g) Which of the following represents the unit displacement vector , $\Delta\hat{\mathbf{r}}_{2p}$?

(1) $< 1/\sqrt{2}\ , 1/\sqrt{2}\ , 1/\sqrt{2} >$

(2) $< 1 , 0 , 0 >$

(3) $< 1 , 1 , 0 >$

(4) $< 1/\sqrt{2}\ , 1/\sqrt{2}\ , 0 >$

(5) $< -1/\sqrt{2}\ , -1/\sqrt{2}\ , 0 >$

(h) Consider the charge distribution with 3 point charges shown in the figure below. All charges have charge **q** = -**e**. Calculate the net electric field at the location of interest **P**.

(1) $\frac{\mathbf{k\,e}}{2}\,\frac{1}{m^2} < \frac{1}{\sqrt{2}}\,,\,\frac{1}{\sqrt{2}}\,,\,\frac{1}{\sqrt{2}} >$ N/C

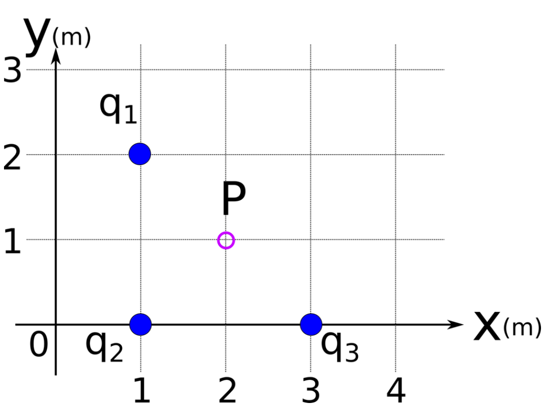
(2) $-\frac{\mathbf{k\,e}}{2}\,\frac{1}{m^2} < \frac{1}{2}\,,\,\frac{1}{2}\,,\,0 >$ N/C

(3) $-\frac{\mathbf{k\,e}}{2}\,\frac{1}{m^2} < \frac{1}{\sqrt{2}}\,,\,\frac{1}{\sqrt{2}}\,,\,0 >$ N/C

(4) $-\frac{\mathbf{k\,e}}{2}\,\frac{1}{m^2} < -\frac{1}{\sqrt{2}}\,,\,-\frac{1}{\sqrt{2}}\,,\,0 >$ N/C

(i) A positive charge $\mathbf{q_o} = 2 \times 10^6$ C is placed at point **P**. What is the electric force on $\mathbf{q_o}$ from the field created by the 3 point charge distribution? (**k** ≈ 9.00×10^9 N m^2/C^2 ; **e** ≈ 1.60×10^{-19} C)

(1) < -1.02 , -1.02 , 0 > μN
(2) < 1.02 , 1.02 , 0 > μN
(3) < -1.44 , -1.44 , 0 > μN
(4) < 1.44 , 1.44 , 0 > μN



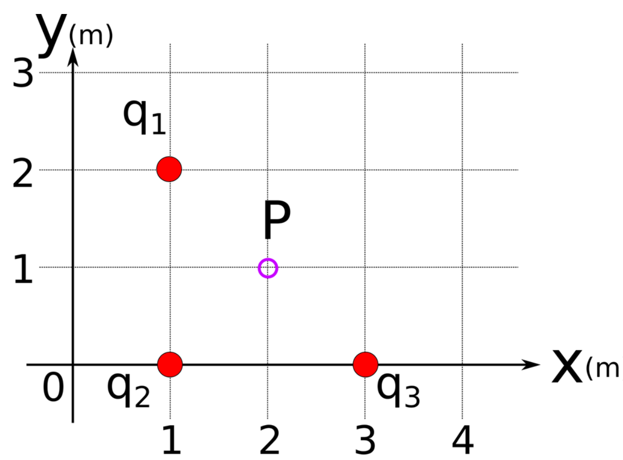
(j) In part **(h)** we found the electric field at point **P**. Which of the following would be the electric field at the same location if all of the charges in the distribution were positive instead of negative?

(1) $\frac{\mathbf{k\,e}}{2}\frac{1}{m^2} < \frac{1}{\sqrt{2}}\ ,\ \frac{1}{\sqrt{2}}\ ,\ \frac{1}{\sqrt{2}} >$ N/C

(2) $-\frac{\mathbf{k\,e}}{2}\frac{1}{m^2} < \frac{1}{2}\ ,\ \frac{1}{2}\ ,\ 0 >$ N/C

(3) $\frac{\mathbf{k\,e}}{2}\frac{1}{m^2} < \frac{1}{\sqrt{2}}\ ,\ \frac{1}{\sqrt{2}}\ ,\ 0 >$ N/C

(4) $-\frac{\mathbf{k\,e}}{2}\frac{1}{m^2} < -\frac{1}{\sqrt{2}}\ ,\ -\frac{1}{\sqrt{2}}\ ,\ 0 >$ N/C



Act III: Approximating Electric Field from Continuous Charge Distributions

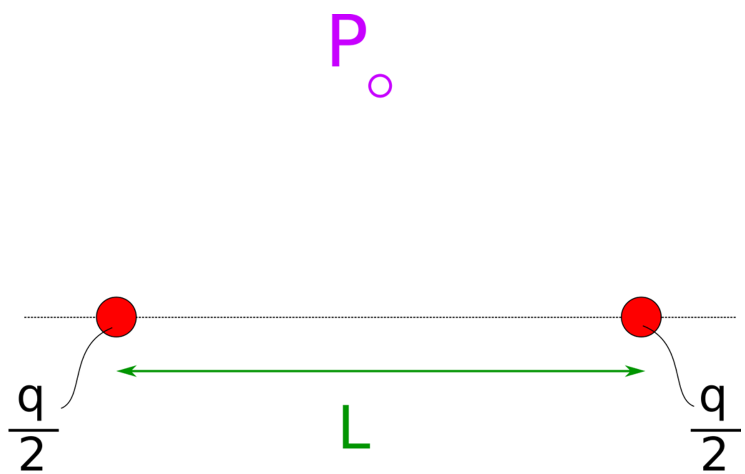
EF.L2.2-05:

Description: Estimate the direction of the electric field from given charge distributions. (3 minutes + 3 minutes + 3 minutes)

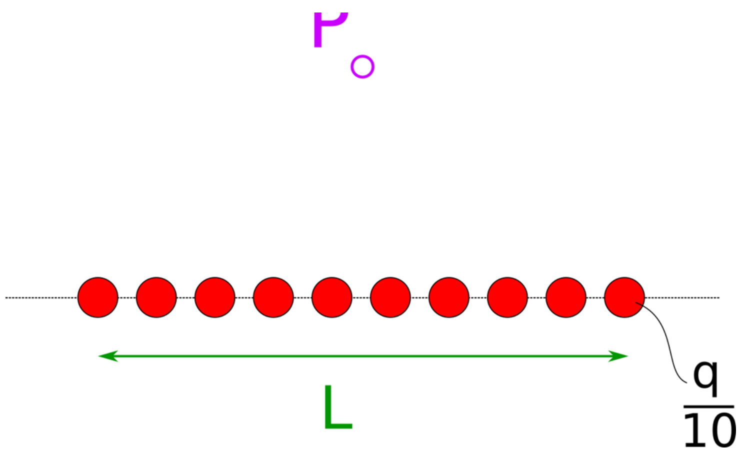
Learning Objectives: [?]

Problem Statement: Sketch the electric field due to the following charge distributions at the location of interest labeled **P**.

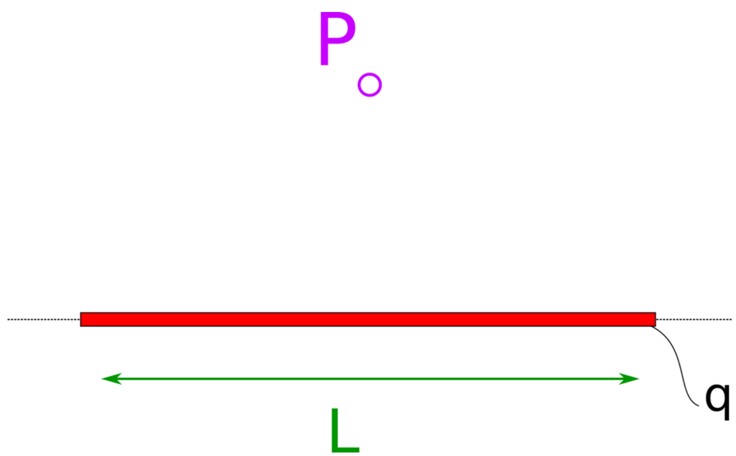
(a) Two point charges are placed along the x-axis as shown in the figure below. Each charge has a charge $\mathbf{q_1} = \mathbf{q_2} = \mathbf{q}/2$.



(b) Ten point charges are placed along the x-axis as shown in the figure below. Each charge has a charge $\mathbf{q_1} = \mathbf{q_2} = \ldots = \mathbf{q}/10$.



(c) A line of continuous charge distribution (i.e. an infinite number of point charges) has it's charge uniformly distributed and lies along the x-axis as shown in the figure below. The net charge on the continuous charged line is **q**.



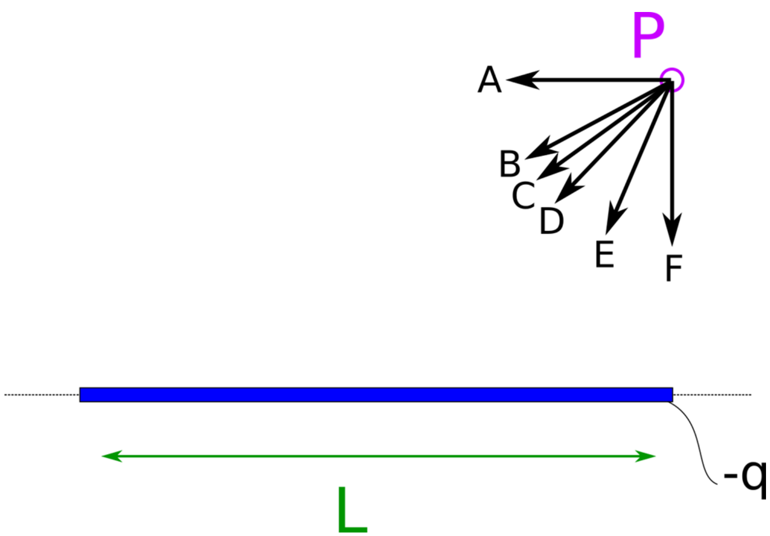
EF.L2.2-06:

Description: Estimate the direction of the electric field from given charge distributions. (4 minutes)

Learning Objectives: [?]

Problem Statement: Consider a short rod carrying a uniformly distributed negative charge. Which vector most closely represents the direction of the electric field at point **P**?

(1) A
(2) B
(3) C
(4) D
(5) E
(6) F
(7) The answer depends on the sign of the charge of the test particle.



Conceptual questions for discussion

1. Coming soon to a lecture template near you.

Hints

EF.L2.2-01: No hints.

EF.L2.2-02: No hints.

EF.L2.2-03: No hints.

EF.L2.2-04: No hints.

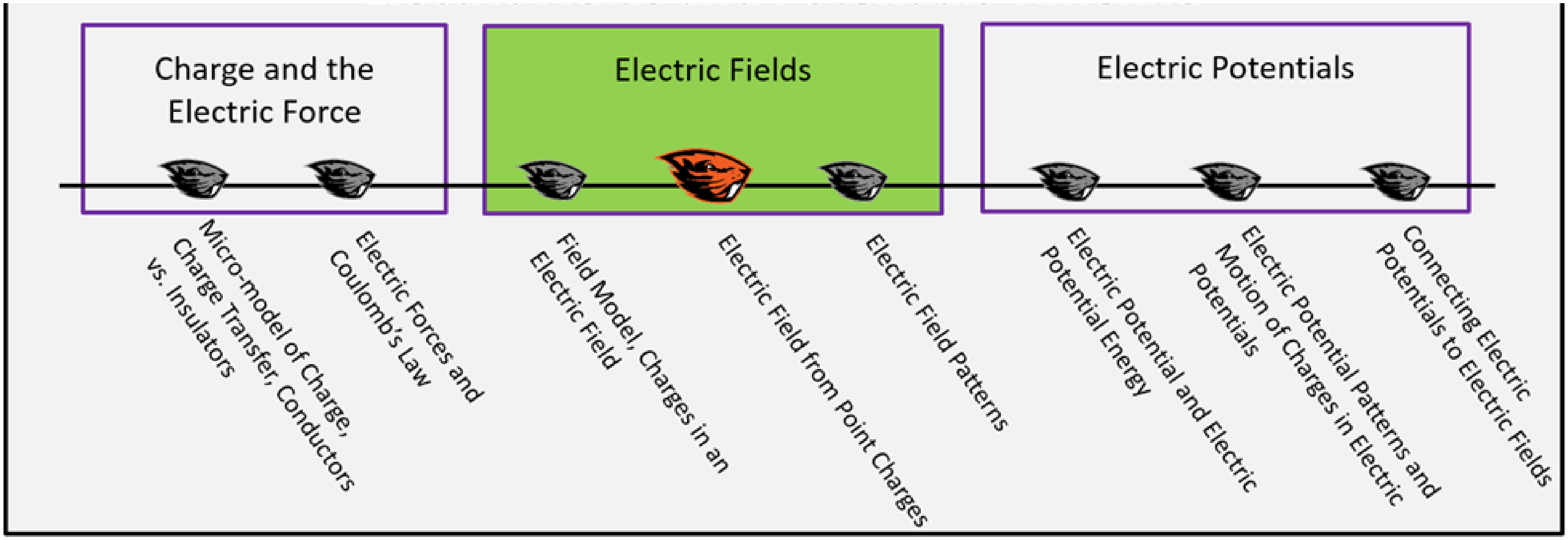
EF.L2.2-05: No hints.

EF.L2.2-06: No hints.

Electric Fields
Practice Stage (EF.L2.3)

Post-Lecture 2
Electric Field from Point Charges

Electric Fields and Potentials Timeline



EF.L2.3-01

Description: Calculate electric field from point charge 1D.

Learning Objectives: [x,xx,…] Put the learning objective numbers here

Problem Statement: Consider a positive charge $\mathbf{q_1}$ = 4 .00 nC that exists in a space far away from other charges. What is the electric field at some pone **P** in space that is 15.0 m to the left of this point charge?

(1) < 24, 0, 0 > N/C

(2) < -24, 0, 0 > N/C

(3) < 16, 0, 0 > N/C

(4) < -16, 0, 0 > N/C

EF.L2.3-02

Description: Calculate electric field from point charge 3D.

Learning Objectives: [x,xx,…] Put the learning objective numbers here

Problem Statement: Consider a negative charge $\mathbf{q_1}$ = -9.00 nC that exists in a space far away from other charges. Let the charge $\mathbf{q_1}$ lie at the origin of a standard coordinate system. What is the electric field at some point **P** in space that has coordinates < 2, -3, 6> m?

(1) < -2.99, 2.99, -2.99 > N/C

(2) < 2.99, -2.99, 2.99 > N/C

(3) < -0.855, 1.28, -2.57 > N/C

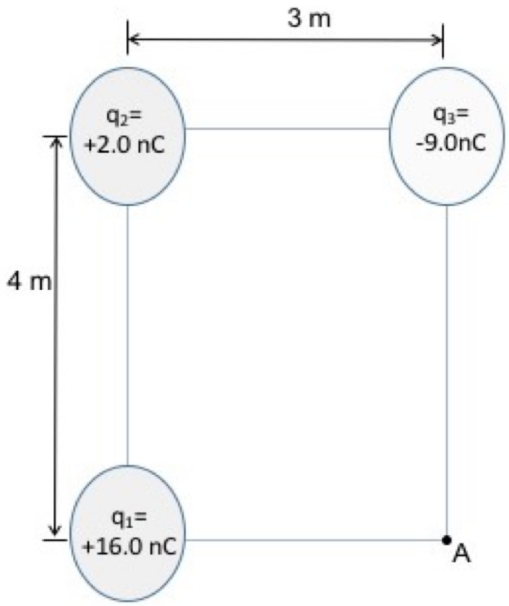
(4) < 0.855, -1.28, 2.57 > N/C

EF.L2.3-03

Description: electrical field calculations

Learning Objectives: [x,xx,…] Put the learning objective numbers here

Problem Statement: Consider this figure. What is the magnitude of the electric field at the location of the +2.0 nC charge from the other two charges?



(1) 18 N/C

(2) 13 N/C

(3) 25 N/C

(4) 20 N/C

(5) 9.0 N/C

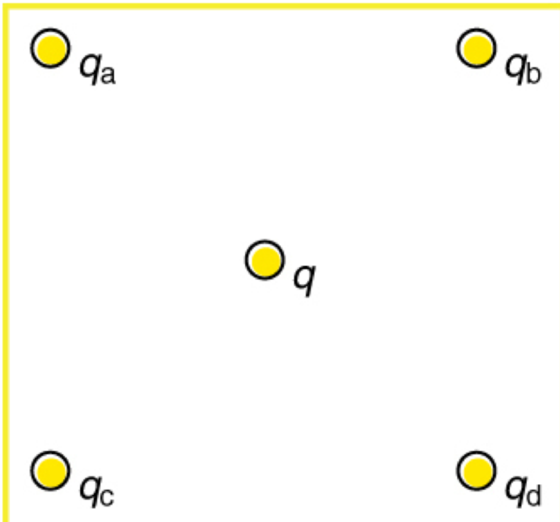
EF.L2.3-04

Description: electrical field calculations

Learning Objectives: [x,xx,…] Put the learning objective numbers here

Problem Statement: Consider the charge configuration in the diagram.

(a) Determine the direction of the electric field at the center of the square in the figure, given that $q_a = q_b = -1.00\ \mu C$ and $q_c = q_d = +1.00\ \mu C$.



(1) The electric field at the center of the square will be to the left.

(2) The electric field at the center of the square will be straight up.

(3) The electric field at the center of the square will be straight down.

(4) There is no electric field at the center of the square.

(b) Calculate the magnitude of the electric field at the location of q, given that the square is 5.00 cm on a side.

(1) 0.00 N/C

(2) 2.88×10^{7} N/C

(3) 2.04×10^{7} N/C

(4) 7.20×10^{6} N/C

EF.L2.3-05

Description: electrical field calculations

Learning Objectives: [x,xx,...] Put the learning objective numbers here

Problem Statement: Find the x-position at which the electric field is zero in the figure.

(1) x = 0.00 cm

(2) x = 2.00 cm

(3) x = -2.00 cm

(4) x = 6.07 cm