PHYS102 - Superposition of Forces

Dr. Suess

January 12, 2007

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PRS Questions
Superposition

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1. If you were in PHYS101 **last semester**, then please pick up your homework sets and exams.
2. By doing this, you free up space in the return boxes thus allowing Barbara to return your final exams.
3. PHYS101 final exams will be ready for pickup once the homework boxes are cleared.
4. THANK YOU.

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PRS Questions

- Question #1
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- Question #3

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PRS Questions

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PRS Questions
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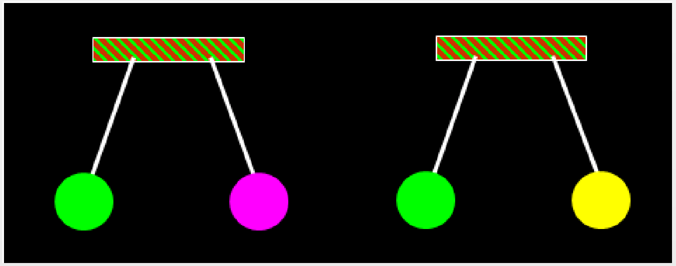
Question #1

From the picture below, what can you conclude about the charges on the colored balls?



1. Purple and Yellow have opposite type charges.
2. Purple and Yellow have the same type charge.
3. Purple, Yellow and Green all have the same type of charge.
4. one ball must be neutral (no net charge).

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Question #1

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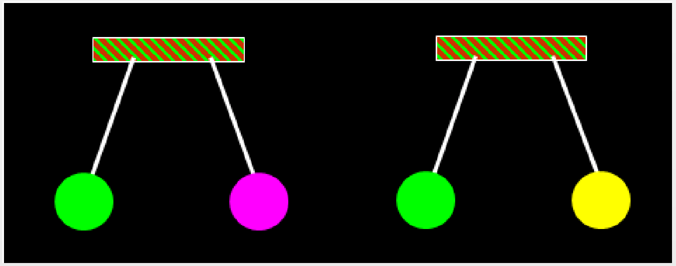

1. Purple and Yellow have opposite type charges.
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Answer: 3. The green and purple balls must have the same type of charge (they repel).

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Question #1

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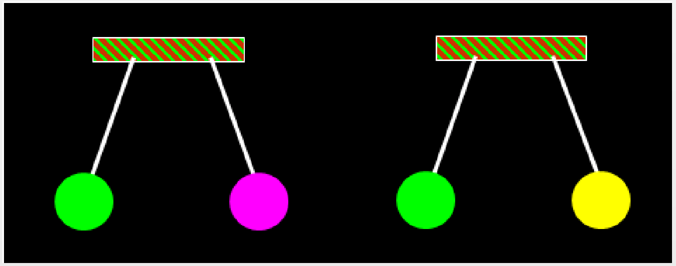

1. Purple and Yellow have opposite type charges.
2. Purple and Yellow have the same type charge.
3. Purple, Yellow and Green all have the same type of charge.
4. one ball must be neutral (no net charge).

Answer: 3. The green and purple balls must have the same type of charge (they repel). The yellow and green balls also repel so they have the same type of charge.

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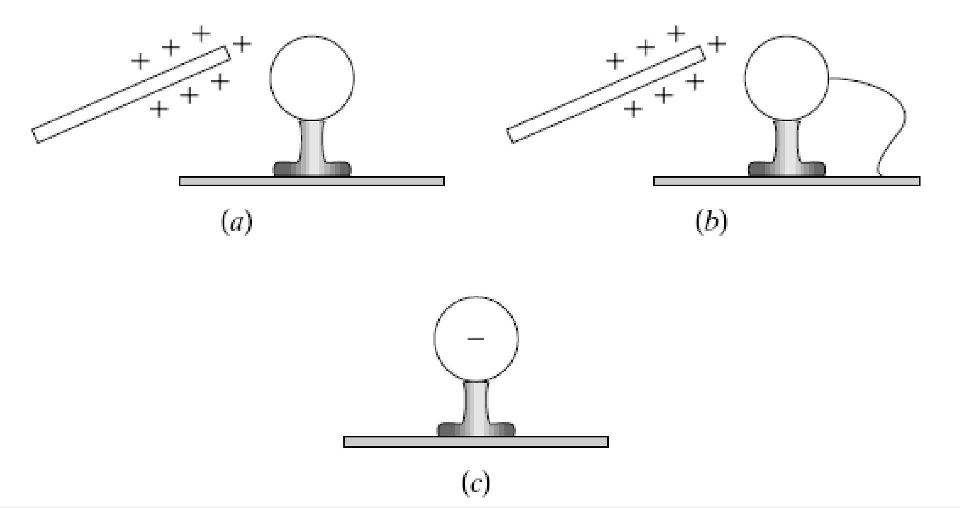
Question #2

A positively charged object is placed close to a conducting object attached to an insulated glass pedestal (a). After the opposite side of the conductor is grounded for a short time interval (b), the conductor becomes negatively charged (c). Based on this information, we can conclude that within the conductor



1. both positive and negative charges move freely.
2. only negative charges move freely.
3. only positive charges move freely.
4. We can't really conclude anything.

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Question #2

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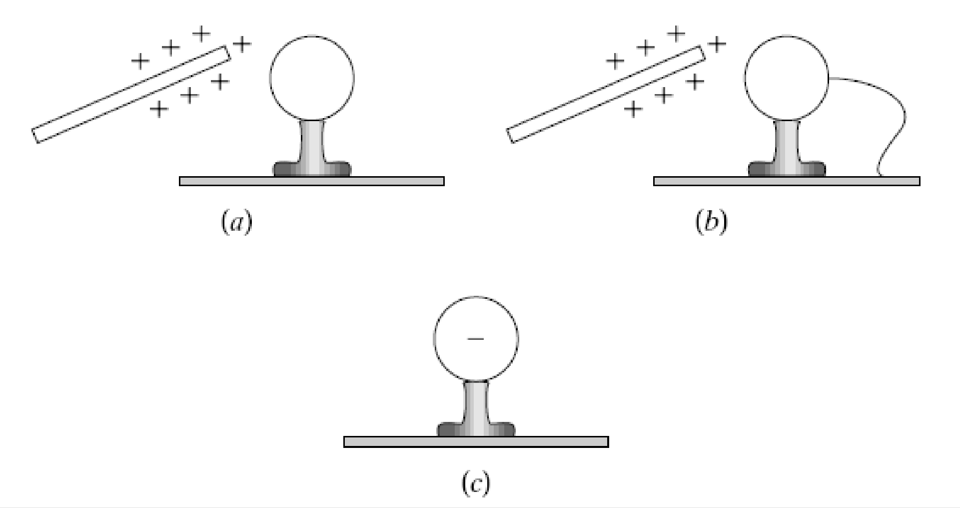

1. both positive and negative charges move freely.
2. only negative charges move freely.
3. only positive charges move freely.
4. We can't really conclude anything.

Answer: 4. The same result is achieved regardless of whether the charge carries are positive or negative.

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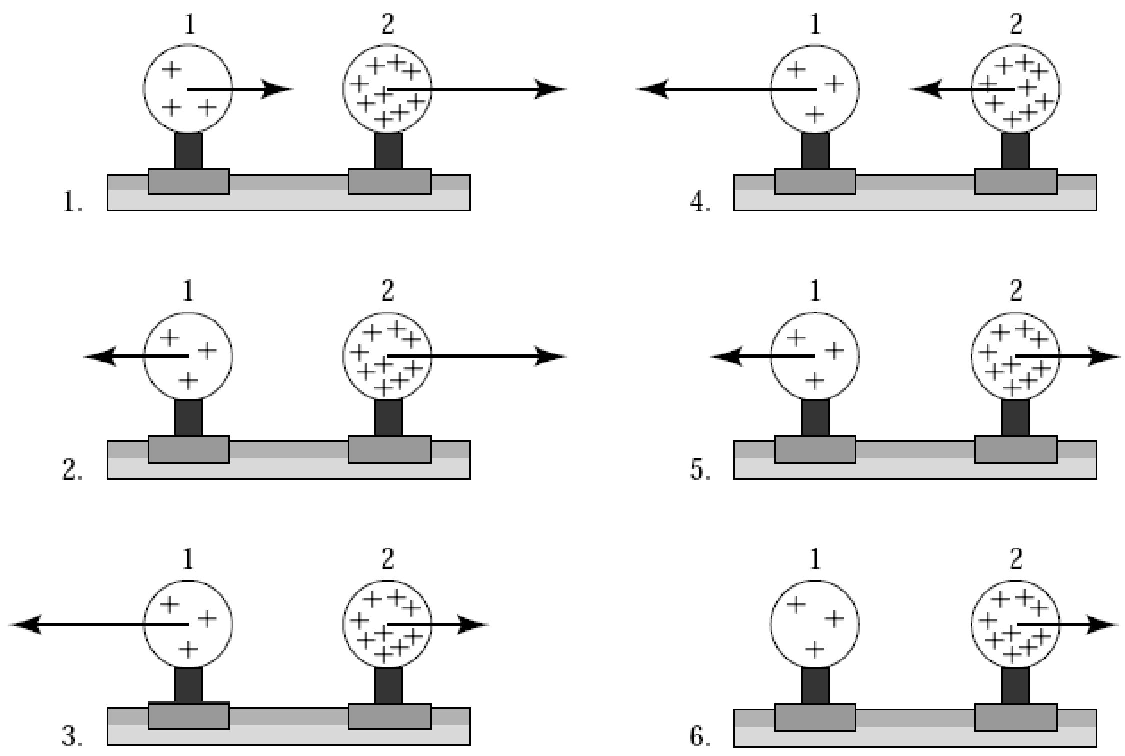
Question #3

Two uniformly charged spheres are firmly fastened to and electrically insulated from frictionless pucks on an air table. The charge on sphere 2 is three times the charge on sphere 1. Which force diagram correctly shows the magnitude and direction of the electrostatic forces:



7. none of the above

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Question #3

Two uniformly charged spheres are firmly fastened to and electrically insulated from frictionless pucks on an air table. The charge on sphere 2 is three times the charge on sphere 1. Which force diagram correctly shows the magnitude and direction of the electrostatic forces:

Answer: 5. The magnitude of the electrostatic force exerted by 2 on i is equal to the magnitude of the electrostatic force exerted by 1 on 2. If the charges are of the same sign, the forces are repulsive; if the charges are of opposite sign, the forces are attractive.

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- Forces - Many Charges
- Superposition
- Adding Forces
- Worked Problem #2

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Forces - Many Charges

- We have obtained a quantitative measure of the force between two charged particles.

Forces - Many Charges

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- We have obtained a quantitative measure of the force between two charged particles.
  - $\vec{F} = \frac{k\, q_1\, q_2\, \hat{r}}{r^2}$

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Forces - Many Charges

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- What happens if we consider three (or more) interacting charges as shown below?

Forces - Many Charges

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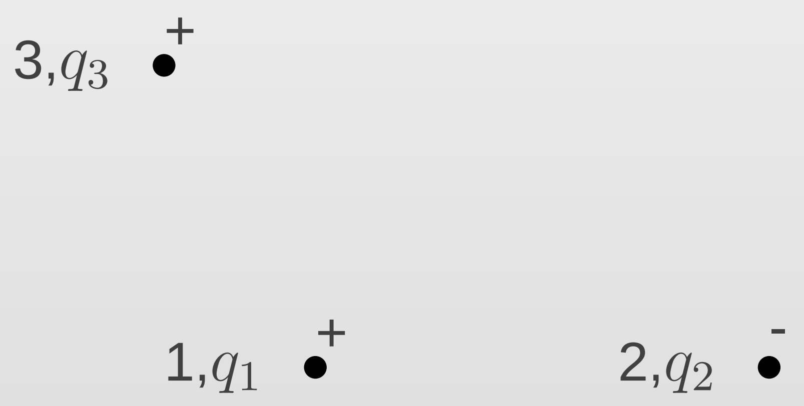

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Continuation from last slide:

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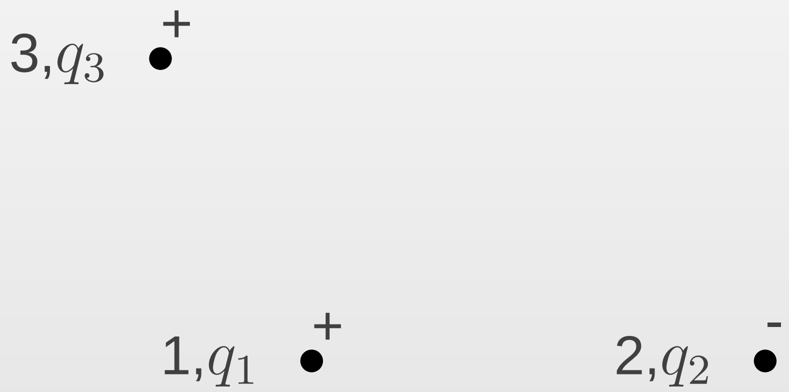
Superposition

Continuation from last slide:

Find the total force experienced by the point particle 1 due to the other two point charges.



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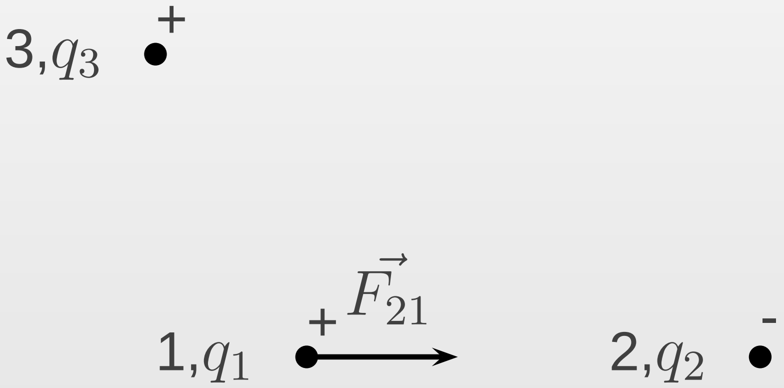

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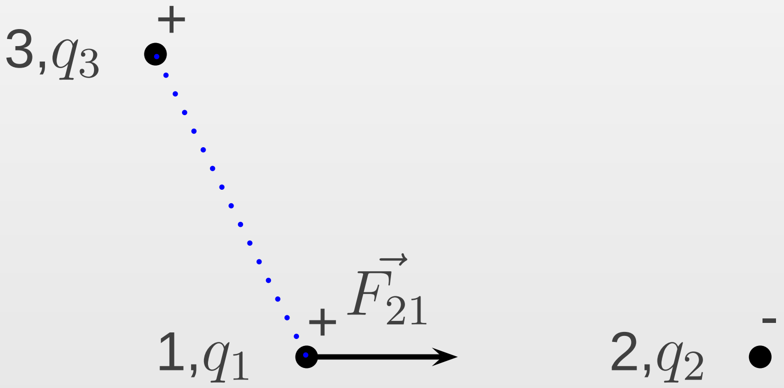

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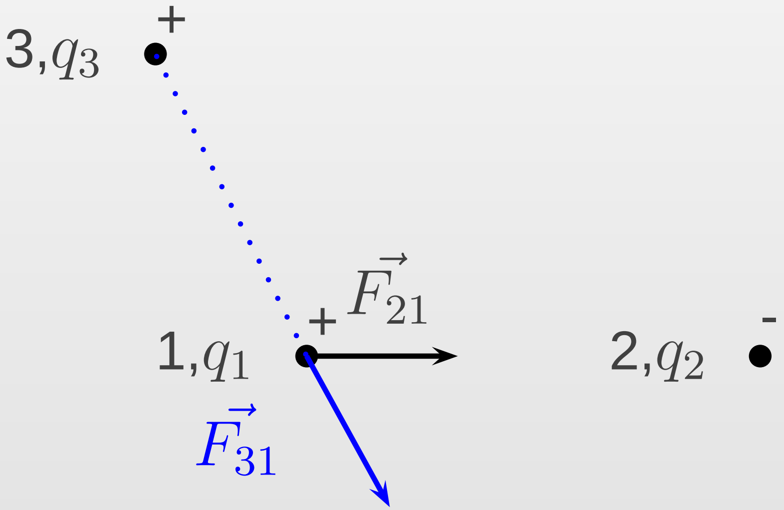

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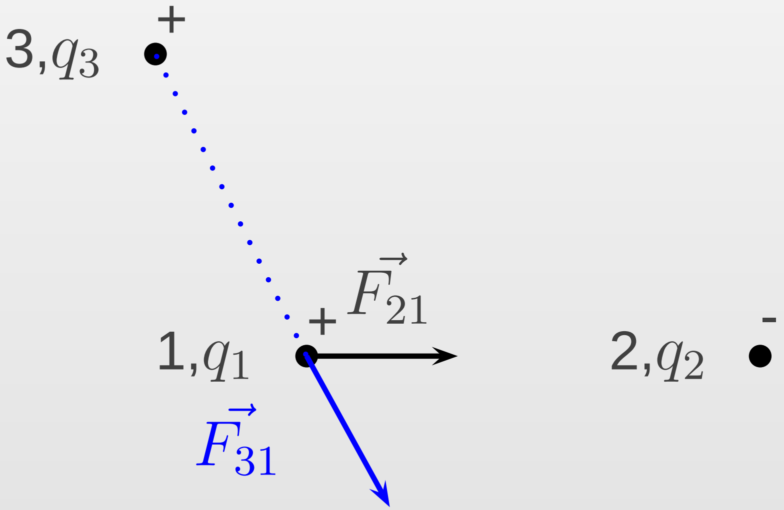

Apply the law of superposition:
$\vec{F}_{\text{TOT},1} = \vec{F}_{21} + \vec{F}_{31}$

Superposition

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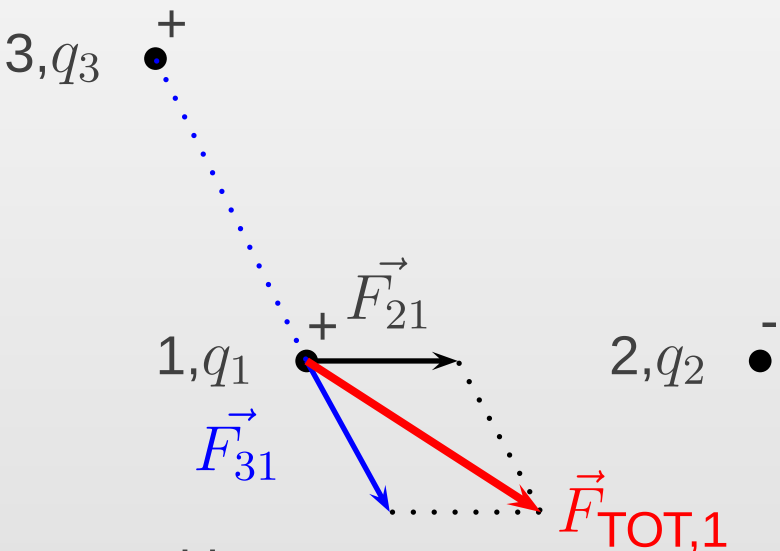

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Adding Forces

- We may generalize from three charged particles at rest to n charged particles.

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- $\vec{F}_{TOT,1} = \sum_n \vec{F}_{n,1} = \sum_n \frac{k\, q_1\, q_n}{r_{n,1}^2}\, \hat{r}_{n,1}$

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  - where $r_{n,1}$ is the distance separating the n^{th} particle with the particle labeled (1).

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- $\vec{F}_{TOT,1} = \sum_n \vec{F}_{n,1} = \sum_n \frac{k\, q_1\, q_n}{r^2_{n,1}}\, \hat{r}_{n,1}$
  - where $r_{n,1}$ is the distance separating the n^{th} particle with the particle labeled (1).

Worked Problem #2

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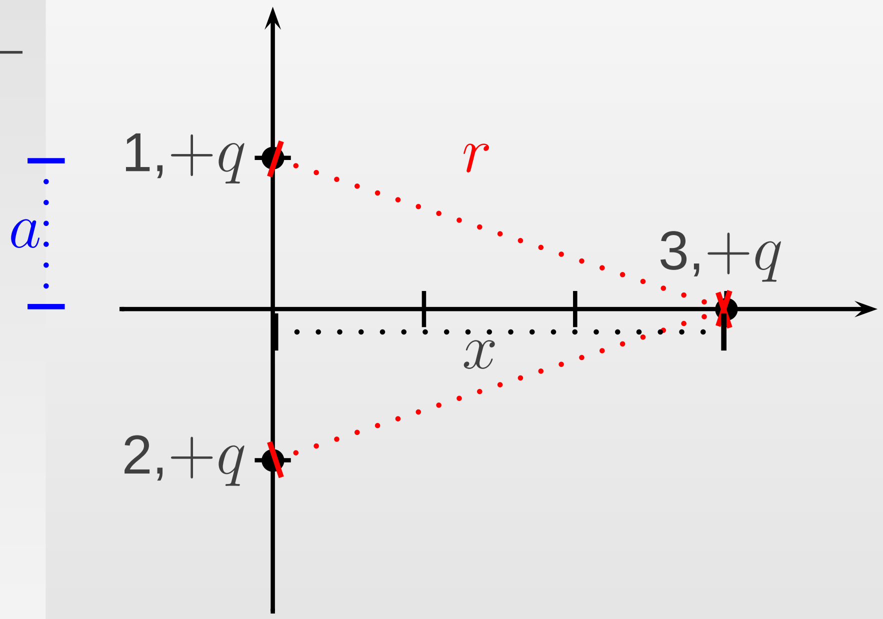

Worked Problem #2

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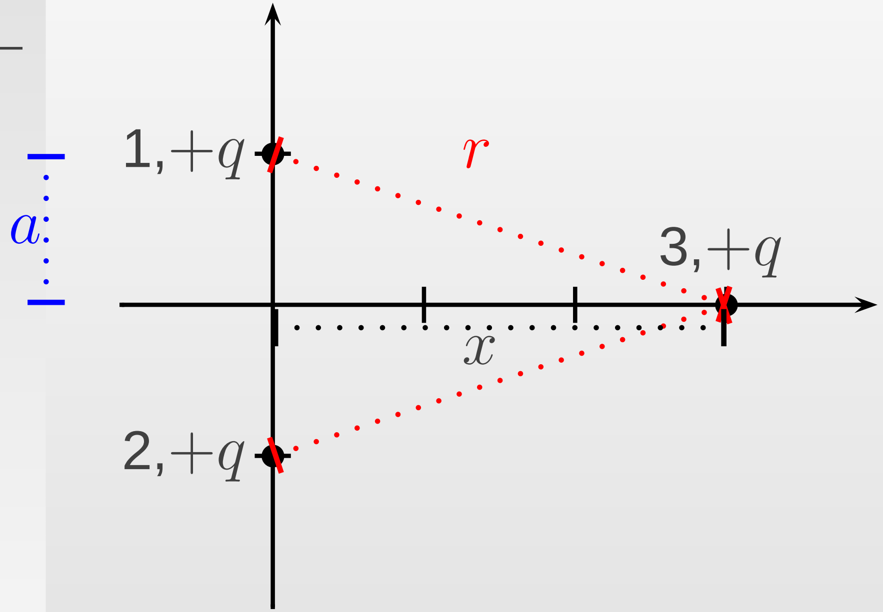

The force on the charge (3) at a distance x from the origin of the coordinate system is given by the vector sum of the forces due to the separate charges.

Worked Problem #2

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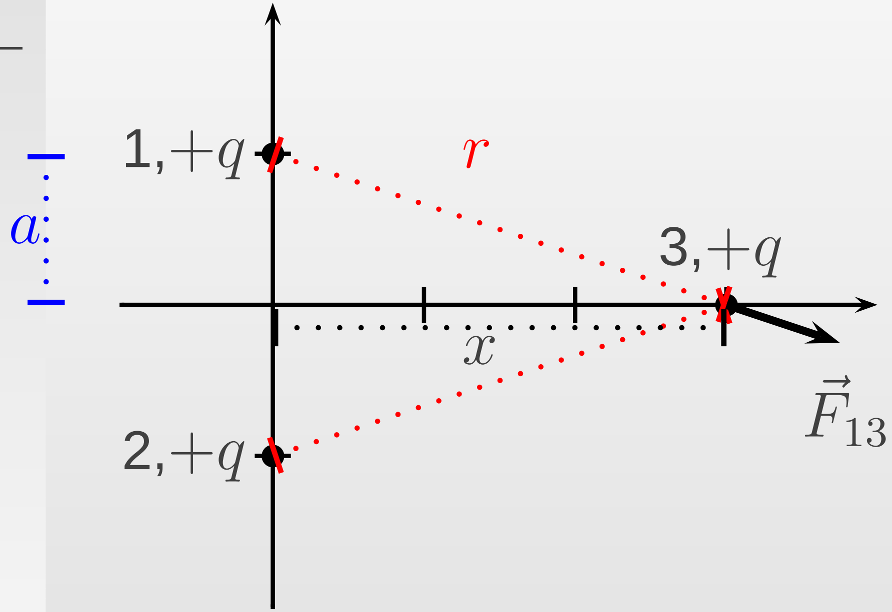

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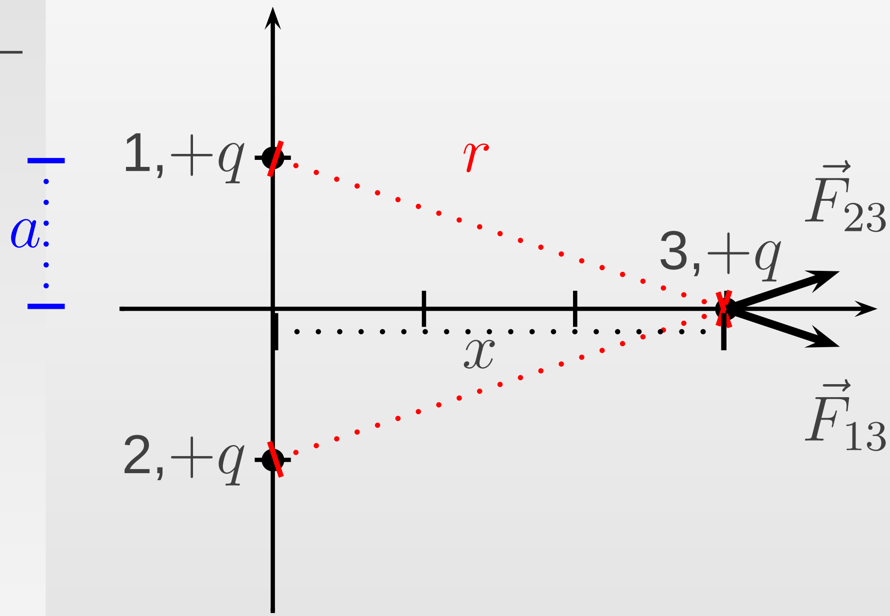

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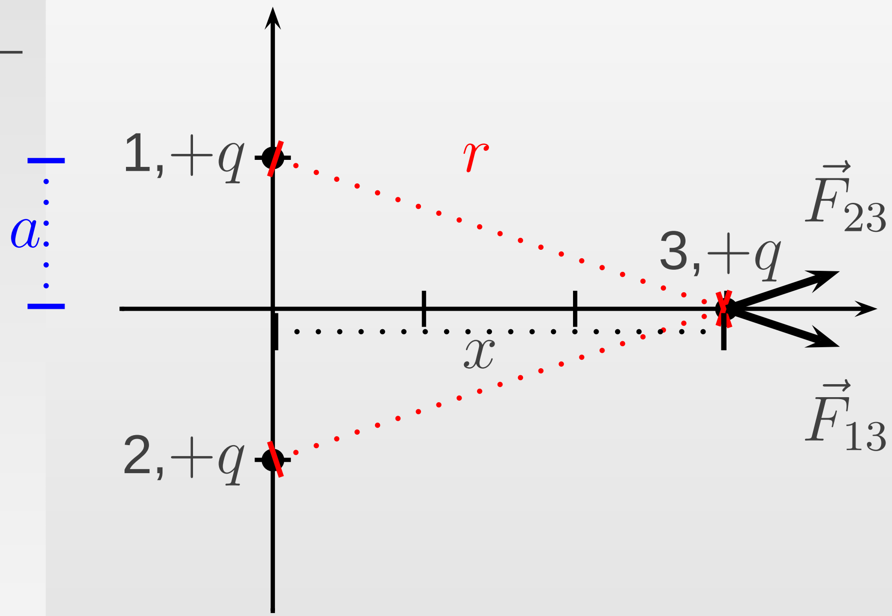

The force on the charge (3) at a distance x from the origin of the coordinate system is given by the vector sum of the forces due to the separate charges.

At a distance x along the x-axis:

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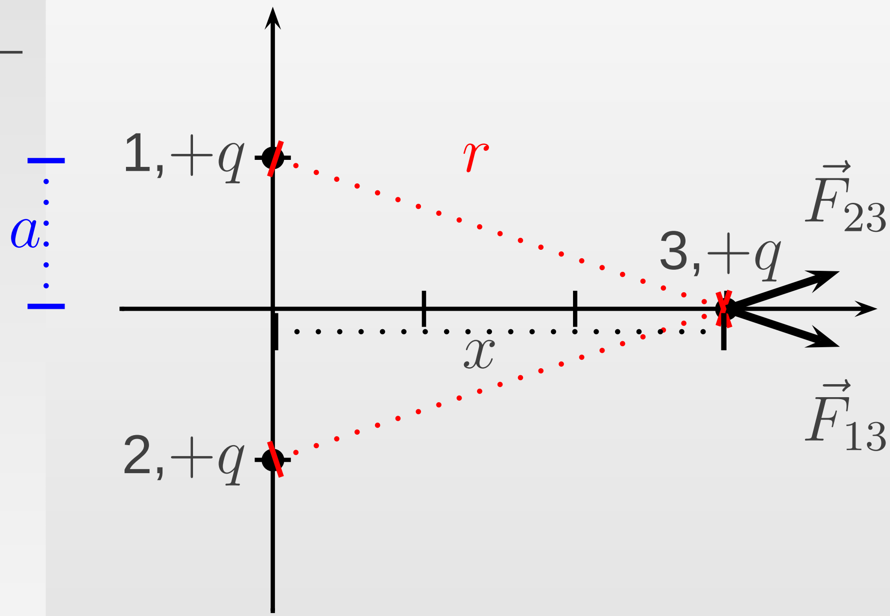

The force on the charge (3) at a distance x from the origin of the coordinate system is given by the vector sum of the forces due to the separate charges.

At a distance x along the x-axis:

$$|F_{23}| = \frac{1}{4\,\pi\,\varepsilon_0}\,\frac{q^2}{(x^2+a^2)}$$