

# Physics 131- Fundamentals of Physics for Biologists I



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**Electrical forces**

## Outline

- Coulomb's law with multiple charges
- Electric Fields
- Feedback from you

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## Forces due to multiple charges an example of vector addition

$$\vec{F}_q = \vec{F}_{Q_1 \rightarrow q} + \vec{F}_{Q_2 \rightarrow q} + \vec{F}_{Q_3 \rightarrow q} + \vec{F}_{Q_4 \rightarrow q} + \dots$$

$$\vec{F}_q = \frac{k_c q Q_1}{r_1^2} \hat{r}_1 + \frac{k_c q Q_2}{r_2^2} \hat{r}_2 + \frac{k_c q Q_3}{r_3^2} \hat{r}_3 + \frac{k_c q Q_4}{r_4^2} \hat{r}_4 + \dots$$

**where**

$r_1$  = distance from  $Q_1$  to  $q$

$\hat{r}_1$  = direction from  $Q_1$  to  $q$  (mag. 1, no units!)

$r_2$  = distance from  $Q_2$  to  $q$

$\hat{r}_2$  = direction from  $Q_2$  to  $q$  (mag. 1, no units!)

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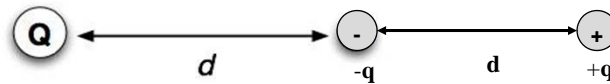
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## Calculate Force on Q

$$q = 1\mu\text{C} \quad Q = 1\mu\text{C} \quad k_c = 9 \times 10^9 \frac{\text{Nm}^2}{\text{C}^2}$$

$$d = 0.3\text{m}$$

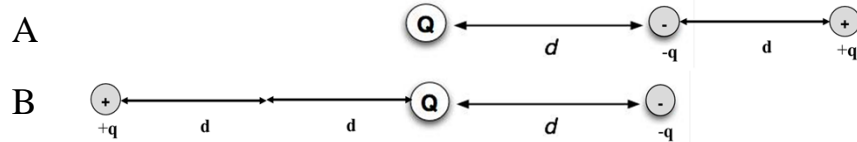


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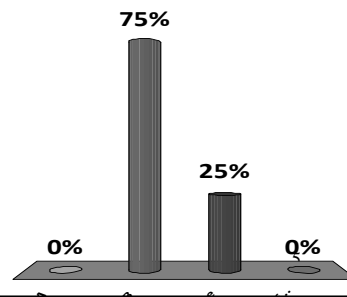
Which is exerting larger force on Q?



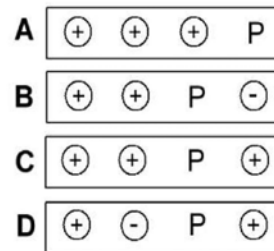
1. A
2. B
3. Same
4. Not enough information

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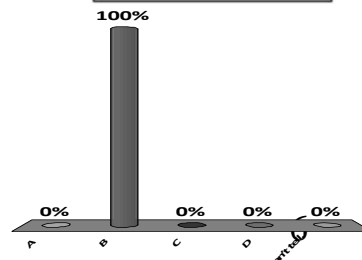
In the figure are shown four arrangements of charge. Each charge has the same magnitude, but some are + and some are -. All distances are to the same scale. In which arrangement would the magnitude of the force felt by a positive test charge placed at P be the largest?



1. A
2. B
3. C
4. D
5. You can't tell.

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## Review of Vectors (2-dimensional coordinates)

- We have 2 directions to specify. We must
  - Choose a reference point (origin)
  - Pick 2 perpendicular axes (x and y)
  - Choose a scale
- We specify our x and y directions by drawing little arrows of unit length in their positive direction.  $\hat{i}, \hat{j}$

- A force vector is written

$$\vec{F} = F_x \hat{i} + F_y \hat{j} = (F_x, F_y)$$

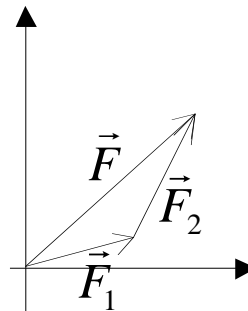
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## Adding Forces in two dimensions

$$\vec{F} = \vec{F}_1 + \vec{F}_2$$



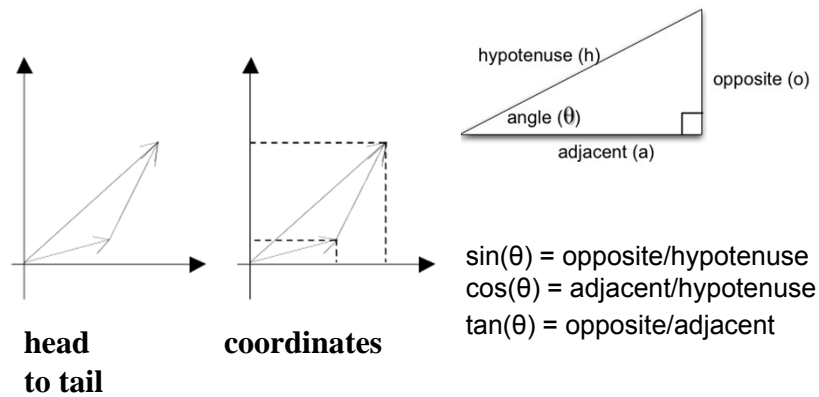
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## Adding Vectors: Methods

### ■ Two mathematical ways to add vectors

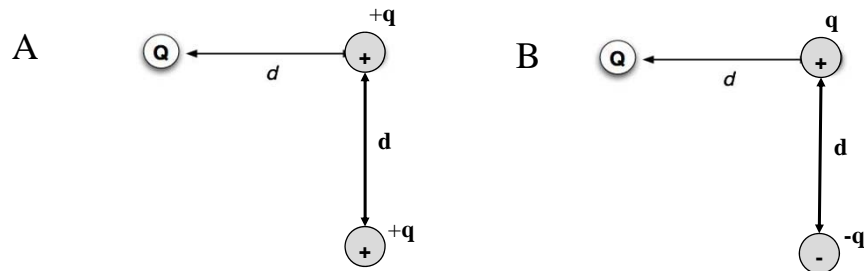


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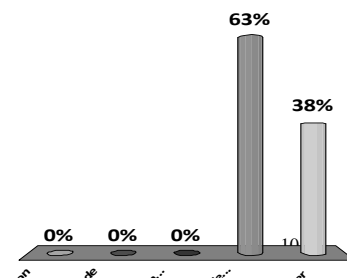
### Compare the magnitude and direction of the net force exerted on Q



1. Same direction
2. Same magnitude
3. Same direction and magnitude
4. Same magnitude, opposite direction
5. neither

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## Feedback

*Readings are not easily accessible.* set up a cumulative readings page so you can review all material. The readings will remain open.

*Reading is ahead of lecture* -> already held off on next reading to keep reading and lecture synchronized!

*Work through example problems in class* -> great suggestion – so far we have done calculation problems in recitation and HW, but we will start to do more calculations in class as well.

*Homework too long and graded harshly* -> Doing additional calculation problems in class should give you more “footholds” to do the HW better, faster

*Please provide optional or supplementary practice problems* -> Already provide two prior exams, will provide more, but we know you have limited time and are spending a lot of time already on practice problems (i.e. HW).

*Questions conceptual but still not applicable, not “real physics problems”, not useful for the MCAT* -> Physics is conceptual as well as mathematical, the MCAT and other exams get much easier if you understand the concepts

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