# Review

charge $\pm$

like sign repel
opposite sign attract

Quantized
smallest is $1.60 \times 10^{-19}$ C ("e")
can have $e, 2e, 3e, \ldots 100e$
not $\frac{e}{2}, 4.5e, \ldots$

2 charged objects affect each other

charged-neutral objects affect each other  polarization

Read 12.3 - 12.4

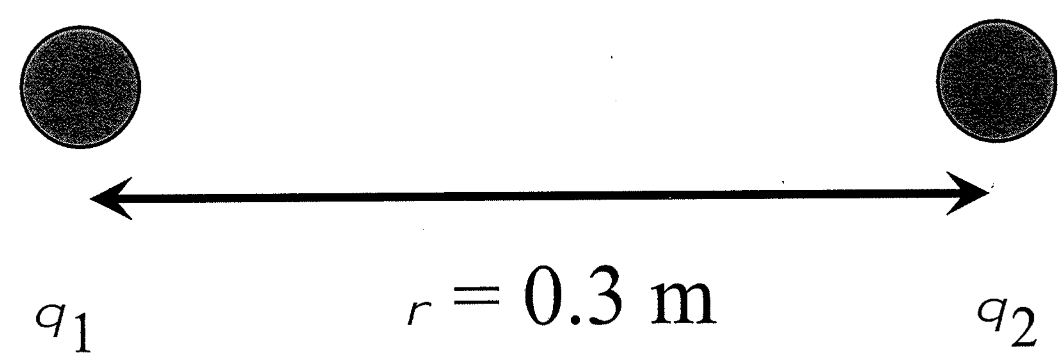
Next HW Available

Exam 2 scores
→ D2L please check
Lp7 scores

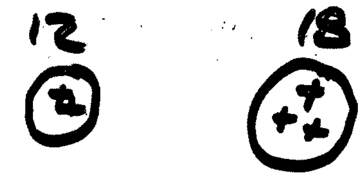
<u>Problem</u>: Two identical spheres hold different charges, $q_1 = 12 \times 10^{-9}$ C and $q_2 = -18 \times 10^{-9}$ C, and are separated by 0.3 m.

(a) What is the electrostatic force on $q_1$ from $q_2$ and what is the force on $q_2$ from $q_1$?

(b) $q_1$ and $q_2$ then touch each other and are put back in their original position. What is the new electrostatic force on $q_1$ from $q_2$ and what is the force on $q_2$ from $q_1$?



$$F = \frac{k q_1 q_2}{r^2} = \frac{(9\times10^{9}\ N\cdot m^2/C^2)(12\times10^{-9}C)(18\times10^{-9}C)}{(.3m)^2}$$




a) $F = 2.2\times10^{-5}N$ magnitude


force on $q_1$ from $q_2$ to right
" $q_2$ $q_1$ to left

b) Total charge $q_1 + q_2 = -6\times10^{-9}C$

$q_1 = -3\times10^{-9}C$

$q_2 = -3\times10^{-9}C$

$$F = \frac{k q_1 q_2}{r^2} = \frac{(9\times10^{9}\ N\cdot m^2/C^2)(3\times10^{-9}C)(3\times10^{-9}C)}{(.3m)^2}$$

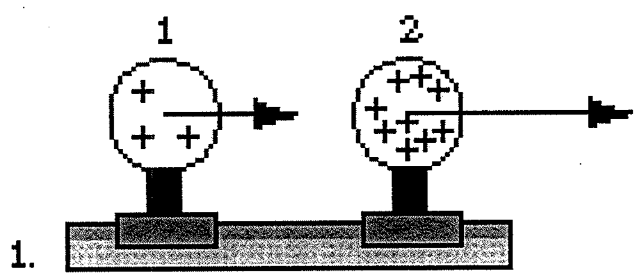

$9\times10^{-7}N$

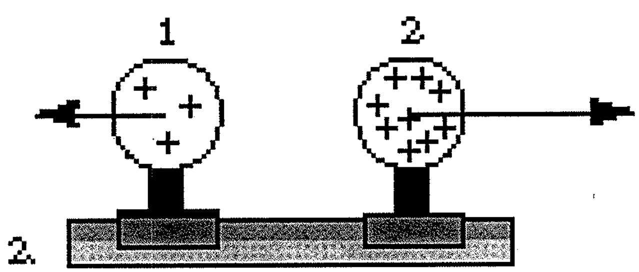
force on $q_1$ from $q_2$ left
on $q_2$ $q_1$ right

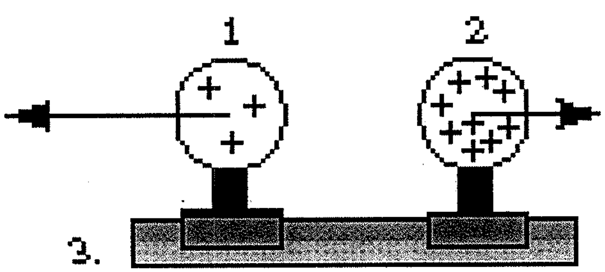
(E)

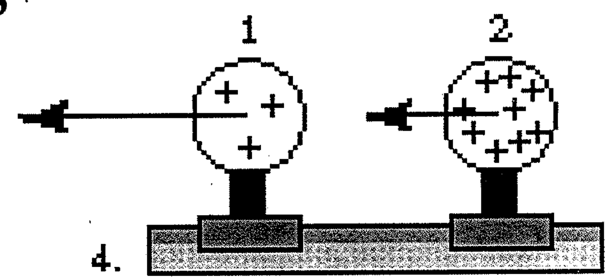
# Interactive Question

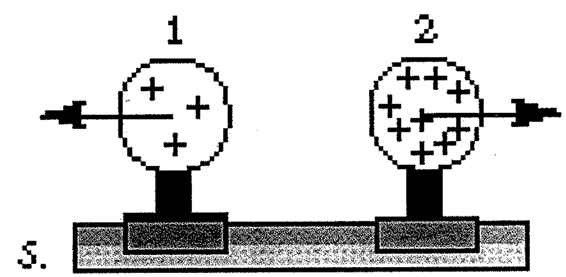
Two uniformly charged spheres are fastened to and electrically insulated from frictionless pucks on an air table. The charge on sphere 2 is three times the charge on sphere 1. Which force diagram correctly shows the magnitude and direction of the electrostatic forces?

A)



B)


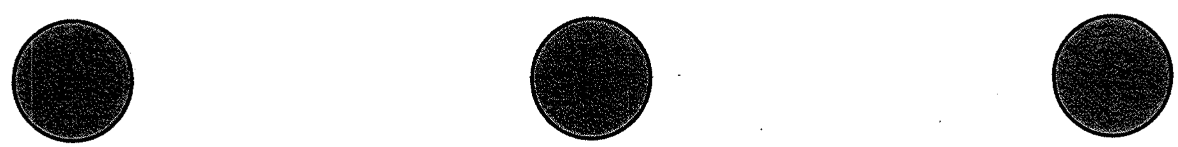

C)


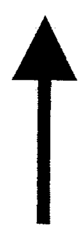
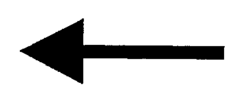

D)



E)


# Interactive Question

Three objects with equal positive charge are placed at equal distance from each other along the x axis. What direction is the net force on the middle object?



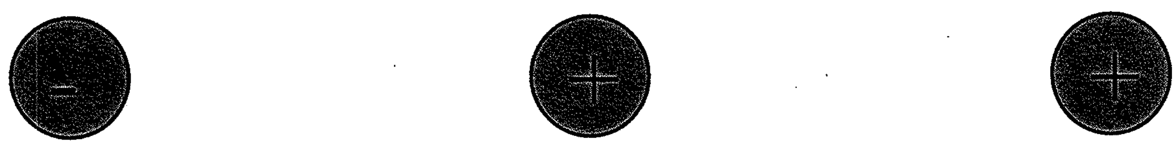
    0

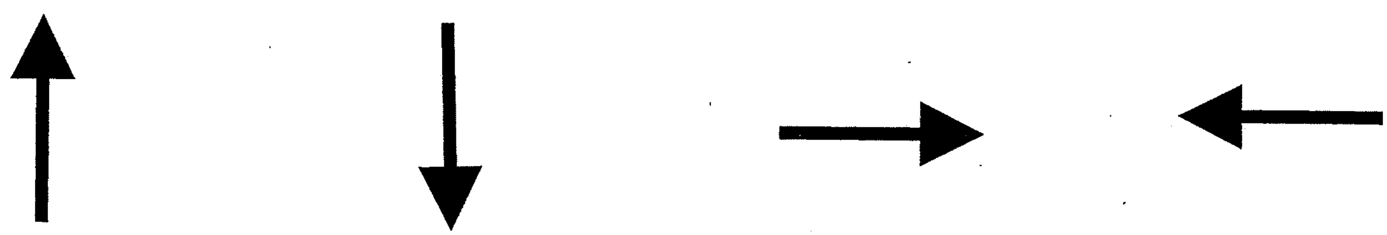
(A) (B) (C) (D) (E)

D

# Interactive Question

Three charged objects are placed at equal distance from each other along the $x$ axis. The objects have the same magnitude of charge with signs as given. What direction is the net force on the middle charge?



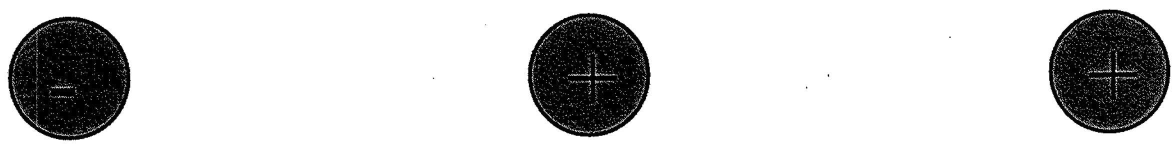
0

(A) (B) (C) (D) (E)

# Interactive Question

(c)

Three charged objects are placed at equal distance from each other along the $x$ axis. The objects have the same magnitude of charge with signs as given. If the two positive charges exert a force of $F$ on each other, what is the total force on the right most charge?

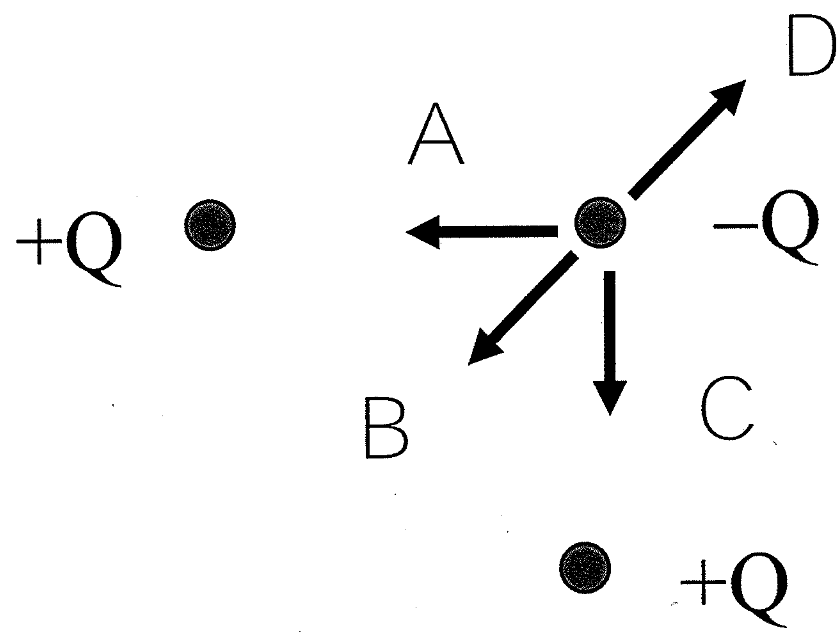


A) $F$ to the right
B) $F$ to the left
C) Less than $F$ to the right, but not zero
D) More than $F$ to the left, but not zero
E) Zero

(B)

# Interactive Question

Three point charges, each with the same magnitude, but with varying signs are arranged at the corners of a square. Which of the arrows shows the directions of the net force that acts on the charge in the upper right hand corner?




A) A
B) B
C) C
D) D
E) The net force on that charge is zero.

Problem: Compare the electrostatic force to the gravitational force between the electron and the proton in a hydrogen atom. The distance between the electron and proton is about $5.29\times10^{-11}$ m.

We will need to use $-q_e = q_p = 1.6\times10^{-19}$ C, $m_e = 9.11\times10^{-31}$ kg, and $m_p = 1.67\times10^{-27}$ kg.

$$F_E = \frac{k q_e q_p}{r^2} = \frac{(9\times10^{9}\ N\cdot m^2/C^2)(1.6\times10^{-19}C)(1.6\times10^{-19}C)}{(5.29\times10^{-11}m)^2}$$

$$8.2\times10^{-8}N$$

$$F_G = \frac{G m_e m_p}{r^2} = \frac{(6.67\times10^{-11}\ N\cdot m^2/kg^2)(9.11\times10^{-31}kg)(1.67\times10^{-27}kg)}{(5.29\times10^{-11}m)^2}$$

$$F_G = 3.6\times10^{-47}N \qquad \frac{F_E}{F_G} = 2.3\times10^{39}$$