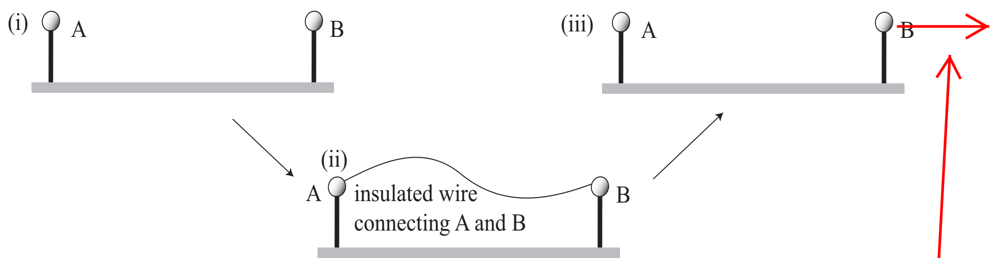
# Physics 102 (F16)

Q1A

**Name:** ____________________ **Section:** __________ **Score:** __________/20

**1**. Very small identical metal spheres A and B are on glass stands placed as in the figure below (i). Initially, A has net charge $2Q$ and B $-4Q$. The magnitude of the Coulomb force between the spheres is $F$. Then, A and B are connected by an uncharged (and insulated) metal wire as (ii) in the figure. After the wire is removed (iii), the magnitude of the force between the spheres becomes $F'$. The distance between the small spheres is kept constant.




(a) What is a very fundamental law (property) of charges we need to determine the charges on the spheres in (iii)? [2].

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Conservation of charges
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(b) Find the ratio $F/F'$ and indicate the direction (in the above figure) of the force acting on B in the final situation (iii) (no justification, no credit!) [~~6~~] 5

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In (iii) A and B have the same charges, so the force must be repulsive.

F = k(2Q)(4Q)/L^2 (magnitude, so you can drop the sign), where L
is the distance (the value does not matter, if positive) between A and B.


The total charge is 2Q - 4Q = -2Q, and this is evenly divided between A
and B, so the charges on the spheres are now -Q:
F' = kQ^2/L.
This implies that
      F/F' = 8.
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(c) What happens to the direction indicated in (b), if the sign of $Q$ is flipped? Answer with clear mentioning of the basic symmetry relevant to the question. [~~2~~] 3

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No change due to the charge conjugation symmetry.
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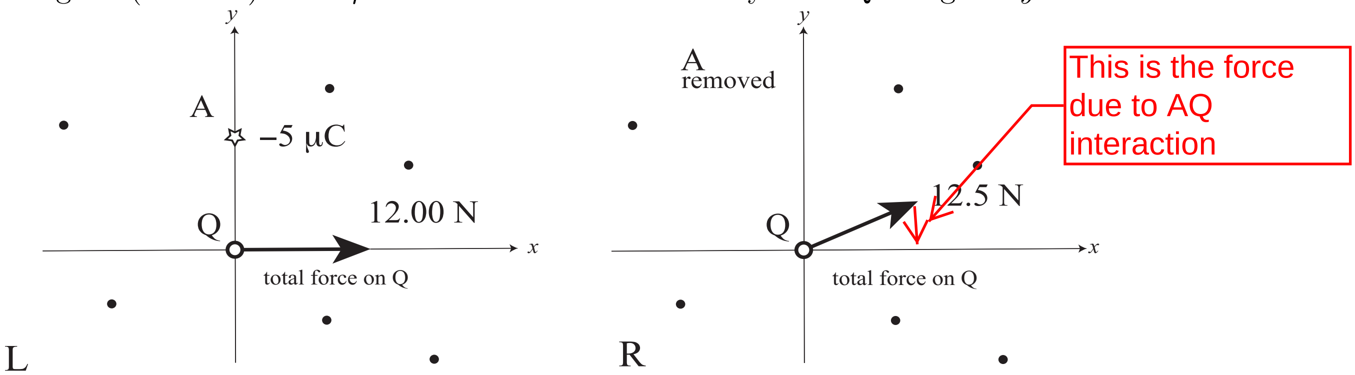
**2**. There are several charges on a plane as shown (as dots and a star) in the figure below left (L). The total electrostatic force acting on charge Q at the origin is 12 N in the $+x$-direction. The charge A (the star) is $-5$ $\mu$C and is located 30 cm away from Q along the $y$-axis.




(a) When the charge Q is doubled, what is the total electrostatic force acting on Q? [2]

Superposition principle tells us that the total force is proportional to Q.

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Hence, the total force is simply doubled:  24 N.
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When the charge A is removed (situation R in the figure above) but all the remaining charges are kept intact, the total electrostatic force acting on charge Q is 12.5 N with the direction in the figure.

(b) What is the sign of charge Q? You must state justification of your answer. [3]

Pay attention to superposition principle

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The difference is due to the force acting on Q due to the presence of A.  If you
add this force to the right force, we get the force in the left.
The red arrow means that A is pushing Q down: a repulsive force. A is negative,
so must be Q.   - charge.
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(c) What is the magnitude of charge Q? You must state justification of your answer. [5]

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The magnitude of the red arrow is, thanks to Pythagoras' theorem
sqrt(12.5^2 - 12^2) = 3.5 N.
Using Coulomb's force (magnitude) formula F = kQQ'/r^2, we get
3.5 = 9x10^9 x Q x (5x10^{-6})/0.3^2, BUT never do this.  Solve Q first:
Q = Fr^2/kQ'.
Therefore,
      Q = 3.5 x (0.3^2)/(9x10^9)(5x10^{-6}) = 3.5 x (1/5)10^{-2-9+6}
        = 0.7 x10^{-5}
or 7 microC.
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