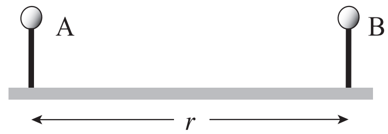
Physics 102 (S16)

Q1B

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

1. Very small metal spheres A and B are on glass stands placed r m apart as in Figure below.



(a) Initially, A and B have certain charges Q and Q', and the electrostatic force between them is 12 N and repulsive. What is the force between them, if the AB distance is halved? [3].

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Coulomb's force: F = kQQ'/r^2 = 12 N.
If r is halved, then F -> F' = kQQ'/(r/2)^2 = 4F = 48 N.
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(b) What is the very fundamental law (property) of charges we need to determine the charges on the spheres after touching ? [2].

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Charge conservation
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(c) After A touches B, they are again isolated and placed r apart as shown in the figure. The magnitude of the force is 16 N. Obtain $x = Q/Q'$ (Assume $Q > Q'$). If you get the equation for x, you get the full credit. [5]

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After touching the charges are both (Q + Q')/2, so the force after touching is
F' = k(Q+Q')/4r^2 = 16N.

From F and F' we get (you may assume Q and Q' are positive thanks to the charge
conjugation symmetry)
      QQ' = 12r^2/k
      (Q + Q')^2 = 64r^2/k
That is
      (Q + Q')^2 = (64/12) QQ' = (16/3)QQ'
If we set x = Q/Q', then
      (x+1)^2 = (16/3)x.
This gives x = 3.
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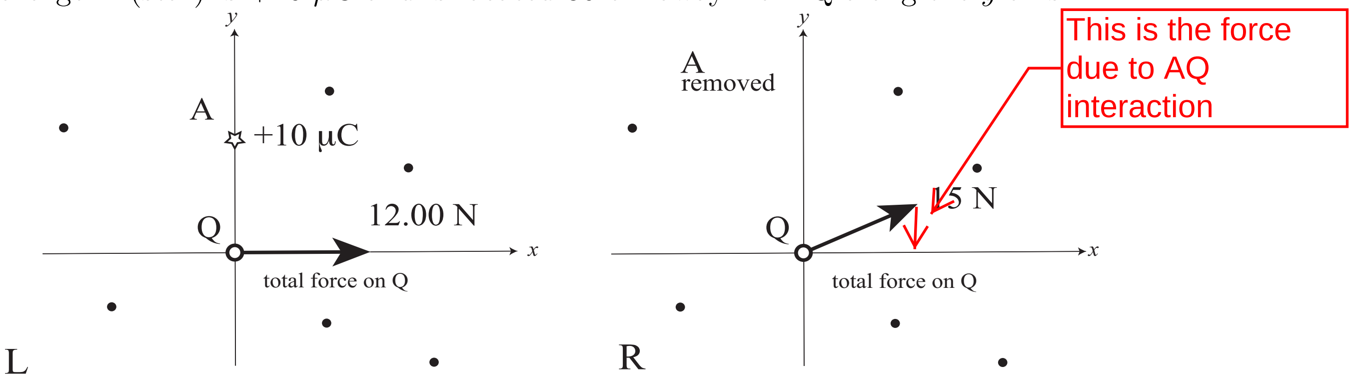
If you write this, you get almost a full score.

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 (star) is $+10$ μC and is located 30 cm away from Q along the y-axis.



(a) When the charge at Q is halved to $Q' = Q/2$, 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 halved:  6 N.
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When the charge at 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 becomes 15 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 removal of charge A.  This increase the `pull' in the
direction of the location of A so the original force must have been repulsive.
Q must have a positive charge.
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(c) What is the magnitude of charge Q? You must exhibit your work neatly. [5]

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The magnitude of the red arrow is, thanks to Pythagoras' theorem
sqrt(15^2 - 12^2) = 9 N.

Using Coulomb's force (magnitude) formula F = kQQ'/r^2, we get
9 = 9x10^9 x Q x (5x10^{-6})/0.3^2, BUT never do this.  Solve Q first:
Q = Fr^2/kQ'.
Therefore,
      Q = 9 x (0.3^2)/(9x10^9)(10x10^{-6}) = 9 x 10^{-2-9+5}
        = 9 x10^{-6}
or 9 microC.
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