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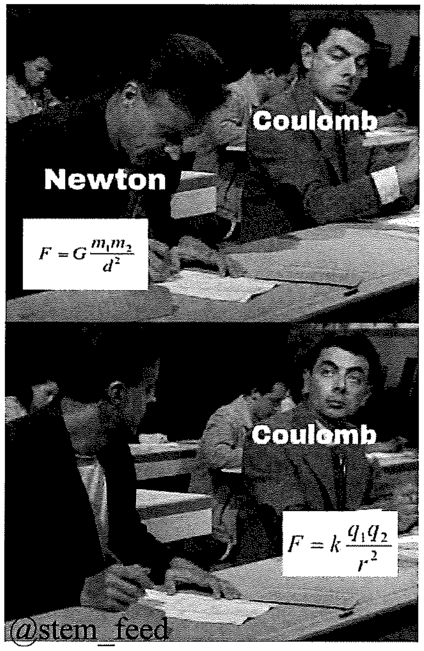
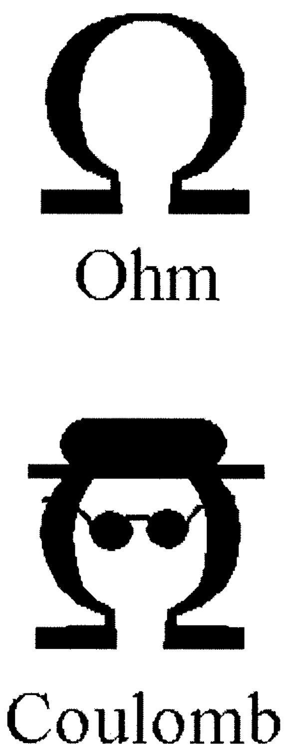
1. Explain each of the following jokes.
   a.



Newton's law of universal gravitation is nearly identical to Coulomb's Law, almost as if Coulomb copied it.

   b.



Coulomb sounds like cool-ohm

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2. A balloon is rubbed on someone's hair, electrons from the hair are transferred to the balloon.
   a. Will the balloon have a negative or positive charge?

   Negative

   b. Will the person's hair have a negative or positive charge?

   Positive

3. A negatively charge object is placed near a positively charged object. Will they be attracted to or repelled by each other?

   Attracted, Opposite charges attract

4. Two negatively charged objects are placed near each other. Will they be attracted or repelled by each other?

   Repelled, like charges repel each other.

5. What is 562 μC in coulombs?

   $562 \times 10^{-6} = 0.000562 C$
   $= 5.62 \times 10^{-4} C$

6. What is 0.00022 C in μC?

   $0.00022 \times 10^{6} = 220 \mu C$

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7. A +5.9 μC object is 0.56 m from a +11.6 μC object.
   a. Will the objects attract each other or repel each other?

   repel, they are both positive

   b. What is the magnitude of the force acting on each object?

$$F_E = \frac{kq_1q_2}{r^2} = \frac{8.988\times10^9 \times 5.9\times10^{-6} \times 11.6\times10^{-6}}{0.56^2} = 1.962\ N$$

$$\approx 2.0\ N$$

8. A -4.6 μC object is 1.9 m from a +4.9 μC object.
   a. Will the objects attract each other or repel each other?

   Attract, opposite charges attract

   b. What is the magnitude of the force acting on each object?

$$F_E = \frac{8.988\times10^9 \times 4.6\times10^{-6} \times 4.9\times10^{-6}}{1.9^2} = 0.056\ N$$

9. A 462 μC object is attracted to another object 1.23 metres away from it with a force of 0.258 N. What is the charge of the second object? Must be negative since it attracts

$$F_E = \frac{kq_1q_2}{r^2} \rightarrow \frac{F_E r^2}{kq_1} = q_2 \rightarrow \frac{0.258\times1.23^2}{8.988\times10^9 \times 462\times10^{-6}} = -9.40\times10^{-8}C$$

$$\text{or } -0.0940\mu C$$

10. A -45.6 μC object is repelled by another object 5.23 metres away from it with a force of 56.3 N. What is the charge of the second object? Must be negative since it repells

$$\frac{F_E r^2}{kq_1} = q_2 \rightarrow \frac{56.3\times5.23^2}{8.988\times10^9 \times 45.6\times10^{-6}} = 0.00376C$$

$$\text{or } 3757\mu C$$

$$\approx 3760\mu C$$

$$-0.00376C \text{ or } -3760\mu C$$

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11. Two 5.3 μC objects ~~attract~~ repel each other with a force of 5.2 N. How far apart are the objects?

$$F_E = \frac{Kq_1q_2}{r^2} \rightarrow r = \sqrt{\frac{Kq_1q_2}{F_E}} = \sqrt{\frac{8.989\times10^9 \times 5.3\times10^{-6} \times 5.3\times10^{-6}}{5.2}}$$

$$= 0.22m$$

12. A 113 μC object is ~~pushed away from~~ pulled towards a -245 μC object with a force of 7.2 N. How far apart are the objects?

$$r = \sqrt{\frac{Kq_1q_2}{F_E}} = \sqrt{\frac{8.988\times10^9 \times 113\times10^{-6} \times 245\times10^{-6}}{7.2}}$$

$$= 5.9m$$

13. About how many times more powerful is the attraction of a 1 C object to a -1 C object due to electric force, compared to the attraction of 1 kg object to a 1 kg object due to gravity?

A: 20 times more

B: 100 times more

C: 5000 times more

D: 100 000 000 000 000 000 000 times more

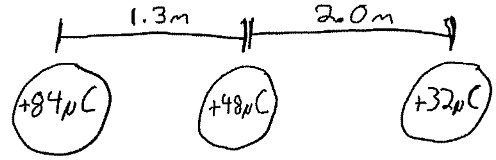
Say they are both 1m apart then

$$F_g = \frac{6.674\times10^{-11} \times 1 \times 1}{1^2} = 6.674\times10^{-11}$$

$$F_E = \frac{8.988\times10^9 \times 1\times1}{1^2} = 8.988\times10^9$$

$$\frac{8.988\times10^9}{6.674\times10^{-11}} = 1.35\times10^{20}$$

14. A +48 μC charge is located 1.3 metres to the right of a +84 μC charge and 2.0 m to the left of a +32μC charge. What is the net force (magnitude and direction) acting on the 48 μC charge.

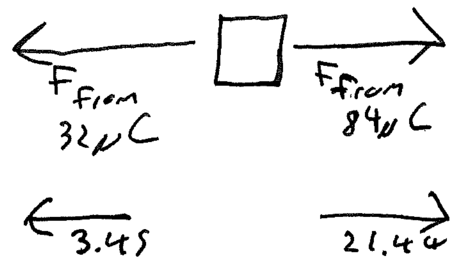


Both forces are repelling

F_{From} 84μC

$$= \frac{8.988\times10^9 \times 84\times10^{-6} \times 48\times10^{-6}}{1.3^2}$$

$= 21.44N$



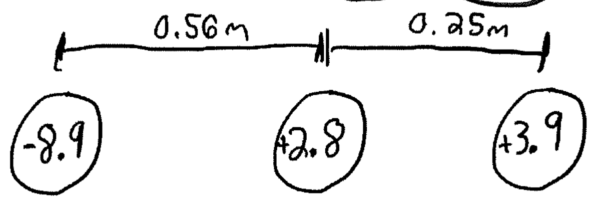
From 32μC

$= 3.45 N$

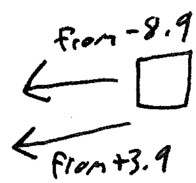
$F_{net} = 21.44 - 3.45 = 17.99N$ right

$\approx$ 18N right

15. A +2.8 μC charge is located 0.56 metres to the right of a $-8.9\mu C$ charge and 0.25 metres to the left of a +3.9 μC charge. What is the net force (magnitude and direction) acting on the +2.8 μC charge?



Both forces push it to left



From -8.9

$$= \frac{8.988\times10^9 \times 8.9\times10^{-6} \times 2.8\times10^{-6}}{0.56^2}$$

$= 0.7142 N$

From 3.9

$$= \frac{8.988\times10^9 \times 3.9\times10^{-6} \times 2.8\times10^{-6}}{0.25^2}$$

$= 1.570 N$

Total

$0.7142N + 1.570N$

$=$ 2.3N left

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16. Two charges are a certain distance apart and are attracted to each other by an electric force of 400.0 N. How will the strength of their attraction change if

   a. The distance between them is doubled?

   Divide by 2^2 $\div \frac{400.0}{4} = 100.0\ N$

   b. The strength of one of the charges is doubled?

   Multiply by 2 $400 \times 2 = 800.0\ N$

   c. The strength of both charges is doubled?

   Multiply by 2 twice $400 \times 2 \times 2 = 1600\ N$

   $= 1.600 \times 10^3\ N$

   d. The distance between them is tripled?

   Divide by 3^2 $\div \frac{400}{9} = 44.44\ N$

   e. The strength of one of the charges is doubled and the distance between them increases by a factor of 5?

   Multiply by 2 and divide by 5^2

   $= \frac{400 \times 2}{25} = 32.00\ N$

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17. A 0.22 kg Styrofoam ball is charged so that it has a $+26\ \mu C$ charge. A rod which has a charge of $-24.5\ \mu C$ is used to levitate the ball so that it floats in the air.

   a. What is the force of gravity acting on the ball?

   $F_g = mg = 0.22 \times 9.8 = 2.156N$
   $\approx 2.2N$

   b. If it is levitating (not moving up or down) what must the net vertical force on the ball be?

   0

   c. What is the electric force from the rod acting on the ball?

   2.2 N

   d. How far from the ball must the rod be placed and should it be placed above or below the ball?

   $F_E = \frac{Kq_1q_2}{r^2} \nearrow r = \sqrt{\frac{Kq_1q_2}{F_E}} = \sqrt{\frac{8.988\times10^9 \times 26\times10^{-6} \times 24.5\times10^{-6}}{2.2}}$
   $= 1.6m$ above
   since it will attract the ball

   e. If the rod had a positive charge how would your answer for d change?

   It would have to be below the ball to provide an upwards force

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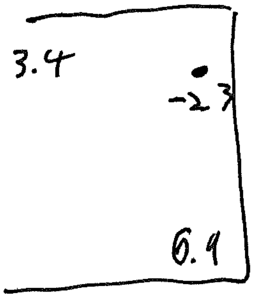
18. A particle with a $-2.3\mu C$ charge is located 0.24 m to the East of a $+3.4\mu C$ charge and 0.36m to the North of a $+6.9\mu C$ charge.



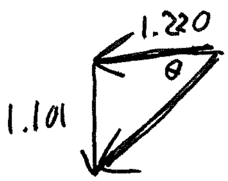
a. What is the force pulling the $-2.3\mu C$ charge to the West?

$$F_E = \frac{8.988\times10^9 \times 2.3\times10^{-6} \times 3.4\times10^{-6}}{0.24^2} = 1.220\ N \approx 1.2N \text{ West}$$

b. What is the force pulling the $-2.3\mu C$ charge to the South?

$$F_E = \frac{8.988\times10^9 \times 2.3\times10^{-6} \times 6.9\times10^{-6}}{0.36^2} = 1.101N \text{ South} \approx 1.1N$$

c. What is the net force acting on the $-2.3\mu C$ charge? (magnitude and direction)



$$\sqrt{1.220^2 + 1.101^2} = 1.643N \approx 1.6N$$

$$\theta = \tan^{-1}\left(\frac{1.101}{1.220}\right) = 42° \text{ South of West}$$

d. If the mass of the particle is 0.025 kg. What will its acceleration be the moment it is released?

$$a = \frac{F_{net}}{m} = \frac{1.643N}{0.025kg} = 66m/s^2$$

e. If the particle is allowed to move freely why will its acceleration not stay at the value found in d.

As it gets closer the electric force will increase.

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19. A 0.25 kg plastic puck is given a charge of +8.3 μC. It sits on a surface with coefficient of static friction between the puck and the surface of 0.26. A rod with a charge of $+6.4\mu C$ is brought near the puck, how close must it get until the puck moves?

Force needed to make it move is $F_{fric} = \mu F_N$

$F_{fric} = 0.26 \times 0.25 \times 9.8 = 0.637N$

F_{Elec} must equal 0.637 to make it move

$$r = \sqrt{\frac{Kq_1q_2}{F_E}} = \sqrt{\frac{8.988\times10^9 \times 8.3\times10^{-6} \times 6.4\times10^{-6}}{0.637}} = 0.87m$$