PY106 Fall 2022 Quiz 1

Yang Jeong Yong

TOTAL POINTS

20 / 20

QUESTION 1

Problem 1 8 pts

1.1 P1 part (a) 2 / 2

✓ **+ 0.5 pts** **Correctly calculated the resultant vector = 10**

✓ **+ 1.5 pts** **Calculated the two individual force vectors correctly. 8kQ^2/L^2 to the right and 6 kQ^2/L^2 down**

- 0.25 pts Added a third force between +4Q and +3Q but this doesn't act on -2Q. There are only two forces acting on -2Q. Or incorrectly identified the forces, but made an attempt.

+ 0 pts Incorrect or blank

1.2 P1 part (b), 1 1 / 1

✓ **+ 1 pts** **Correct: Magnitudes are the same for each case. Force vector in the "x" direction remains the same. Force vector in the "y" direction flips direction. Both vectors have the same magnitudes in each case, so the resultant will also have the same magnitude.**

+ 0 pts Incorrect

1.3 P1 part (b), 2 1 / 1

✓ **+ 1 pts** **Less than 90 degrees apart (keep track of vector components). Force vector in Case A has an angle <45 degrees below horizontal. Force vector in Case B has an angle <45 degrees above horizontal.**

+ 0.3 pts 90 degrees apart is "close", but doesn't recognize that the components, and the resultant vectors from these components, are such as described above.

+ 0 pts Any other answer

1.4 P1 part (c) 1 / 1

✓ **+ 1 pts** **Correct: negative. There are three pairs: -8kQQ/L -6kQQ/L +.707*12kQQ/L. Sum is negative.**

+ 0 pts Incorrect

1.5 P1 part (d) 1 / 1

✓ **+ 1 pts** **Correct: Negative. There are three pairs: -8kQQ/L + 6kQQ/L -.707*12kQQ/L**

+ 0 pts Incorrect

1.6 P1 part (e) 1 / 1

✓ **+ 1 pts** **Correct: -5. For V's, they all have the same denominator: sort(2) L / 2. So, we can just add each numerator: +kQ +k#q - k2Q -kxQ = 0. x = -5.**

+ 0.5 pts Added up the potentials, but made a math error and did not get the final result

+ 0 pts Incorrect

1.7 P1 part (f) 1 / 1

✓ **+ 1 pts** **Correct: X (cannot be done). At the center, the vectors of the individual electric fields will never cancel out along the +4Q and +3Q axis. So it doesn't matter what you do in the bottom corner.**

+ 0.5 pts Incorrect: If place -2Q in the bottom left corner, at the center that will cancel out the electric field vector along the top right, bottom left axis. But that's not enough (see above).

+ 0 pts Incorrect

QUESTION 2

Problem 2 6 pts

2.1 P2 part (a) 1 / 1

✓ **+ 1 pts** **55 V and 45 V. 5 cm apart, and the E field is 100 V/m which is 1 V / cm. Since the equipotential lines are 5 cm apart, there are 5 volts separating each. Electric field is pointing down, so greater**

potential at the top than at the bottom. Electric field vector points in the direction of decreasing potential (which is down).

+ **0.4 pts** Something close... but math error, but still higher potential above 50 than below 50.

+ **0.4 pts** Made 0 volts at the bottom, so split it with 100 V on top. But this isn't consistent with E = 100 V/m

+ **0.4 pts** Gave potentials that was consistent with electric field pointing up (i.e., 45 on top and 55 on bottom).

+ **0 pts** Incorrect

2.2 P2 part (b) 1 / 1

✓ **+ 1 pts Correct: Negative. F = qE (F and E are vectors). E is pointing down. If we want an electric force pointing up, then q must be negative in order to flip the direction.**

+ **0 pts** Incorrect

2.3 P2 part (c) 2 / 2

✓ **+ 1.5 pts Correct: |q|= 10^-7 C. +Fe - Fg = 0. |qE| = mg. |q| = mg/|E| = (10^-6 kg)(10 N/kg)/(100 V/m)**

✓ **+ 0.5 pts Drew a FBD with Fe up and Fg down, or otherwise set up the problem consistent with this... made a good start at this problem**

+ **1 pts** Otherwise correct, but made a small math error

+ **0 pts** Incorrect

2.4 P2 part (d) 2 / 2

✓ **+ 0.5 pts Correct: Newton's 2nd Law net F = ma. q being 10% larger, means there will be unbalanced forces, and Fe will be greater than Fg and the spider will have an upward acceleration. Fe - Fg = ma. a = (1.1 qE - mg)/m = 1.1qE/m - g = (1.1E-7 C)(100 V/m)/(10E-6 kg) - 10 N/kg = 1 m/s/s.**

✓ **+ 1.5 pts Drew a FBD with Fe up and Fg down, knew that the forces were unbalanced, set equal to ma, and started on the right track.**

+ **1 pts** Attempted to solve for acceleration without taking into affect acceleration due to gravity (or started to set up the problem in a reasonable way)

+ **0 pts** Incorrect

QUESTION 3

Problem 3 6 pts

3.1 P3 part (a) 2 / 2

✓ **+ 1 pts Correct final answer: +3a. E = -4kQ/(x+3a)^2 + 1kQ/x^2. Cross multiply and solve**

✓ **+ 1 pts Correct: In the region to the right of +q.**

+ **0.5 pts** Started the problem by adding individual electric field vectors, but did not arrive at the correct region or set it up quite correctly

+ **0 pts** Incorrect

3.2 P3 part (b) 2 / 2

✓ **+ 1 pts Correct: V = 0 at two places along the x-axis, in between the two charges and to the right of the +Q charge. But we only need one. If pick between, choose x, then distance from +Q is x and distance from -4Q is 3a-x. If pick to the right of +Q, choose x, then distance from +Q is x and distance from -4Q is 3a+x. This will yield two results x = -0.6 a and x = +1a.**

✓ **+ 1 pts Started by setting up the problem**

+ **0 pts** Incorrect

3.3 P3 part (c) 1 / 1

✓ **+ 1 pts Correct: Drew a rough oval around +Q (surrounding +Q), shading everything**

+ **0.5 pts** Not correct, but had the right idea

+ **0 pts** Incorrect

3.4 P3 part (d) 1 / 1

✓ **+ 1 pts Correct: Forces are equal and opposite (Newton's 3rd law)**

+ **0 pts** Incorrect

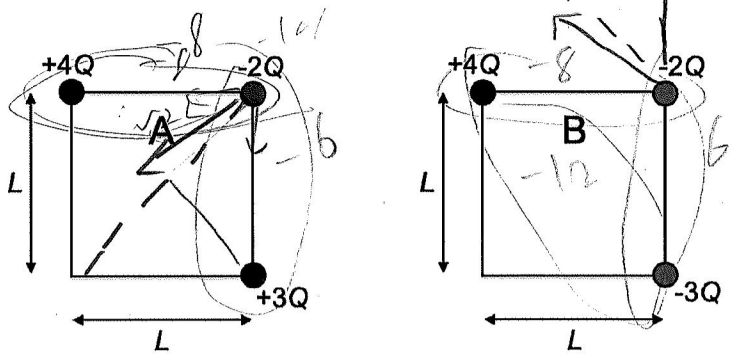
PY106 Quiz 1 September 28, 2022

NAME: Jeong Yong Yang **ID NUMBER:** U95912941

Show your work and put final answers in the boxes provided. You must show work to earn credit.

PROBLEM 1 – 8 points

There are two cases (A and B) showing charged particles placed at three corners of a square. The only difference between Case A and Case B is the sign of the charge at the bottom right corner. In each case, assume the particles only interact with each other, and neglect gravitational interactions.



[2 points] (a) In Case A, determine the magnitude of the net force acting on the $-2Q$ charge. Express your answer as a numerical value in front of the expression written in terms of k, Q, and L.

$F_{net} = F_1 + F_2$

$= \frac{(4Q)(-2Q)k}{L^2} + \frac{(3Q)(-2Q)k}{L^2}$

$= -\frac{8Q^2k}{L^2} + \frac{(-6Q^2)k}{L^2}$

$\left(\sqrt{(-8)^2+(-6)^2}\right)\left(\frac{kQ^2}{L^2}\right)$ ← since force is a vector

$= 10\,\frac{kQ^2}{L^2}$

$|F_{net}| =$ 10 $\frac{kQ^2}{L^2}$

[2 points] (b) How does the net force on the $-2Q$ charge in Case A compare to the net force on the $-2Q$ charge in Case B?

The magnitudes of these two forces are ... [✓] the same [ ] different

The directions of the two forces are ... [ ] the same [✓] less than 90° apart [ ] 90° apart

[ ] more than 90° and less than 180° apart [ ] 180° apart

[1 point] (c) The total electric potential energy of the set of three charges in Case A is ...

[ ] positive [✓] negative [ ] zero

[1 point] (d) The total electric potential energy of the set of three charges in Case B is ...

[ ] positive [✓] negative [ ] zero

[1 point] (e) In Case A, let us say you place a fourth charge at the bottom left corner of the square. What should that charge be so the net electric potential at the center of the square is zero? If you determine it cannot be done, put an X in the answer box.

charge = −5 Q

net electric potential = 0

$V_{net} = 0$

$= \frac{k(4Q)}{\sqrt{2}/2L} + \frac{k(3Q)}{\sqrt{2}/2L} + \frac{k(-2Q)}{\sqrt{2}/2L} + \frac{k(xQ)}{\sqrt{2}/2L} \rightarrow \frac{-xQk}{\sqrt{2}kL} = \frac{5kQ}{\sqrt{2}kL} \rightarrow x = -5$

[1 point] (f) In Case A, let us say you place a fourth charge at the bottom left corner of the square. What should that charge be so the net electric field at the center of the square is zero? If you determine it cannot be done, put an X in the answer box.

charge = X Q

4Q −2Q
0 0
3Q
xQ 0 3Q

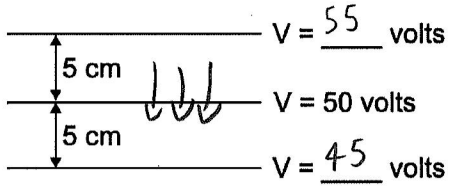
The electric field of 4Q is stronger than the field of 3Q. In order to cancel out electric field of −2Q, the fourth charge should have charge of negative, with the same magnitude → −2Q. In this case, the field from 4Q can never get canceled since it is greater than field of 3Q.

↓↓↓

PROBLEM 2 – 6 points

At the surface of the Earth, there is a uniform electric field directed down of 100 V/m. There is also a uniform gravitational field, of 10 N/kg, directed down. Some spiders can make use of the electric field to basically balloon large distances through the air, driven horizontally by wind currents. We will model that process here. *Hint: for (b) – (d), a free body diagram drawn on your equation sheet may be helpful.*

[1 point] (a) The equipotential lines in the diagram are 5 cm apart, and the middle one is labeled as being 50 volts. On the figure, fill in the voltage values for the other two lines, consistent with an electric field of 100 V/m directed down.

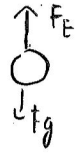


$100 V/m \left(\frac{1m}{100cm}\right) = 1 V/cm$

[1 point] (b) To create an upward force on itself, the spider sends out a piece of silk straight up. The silk ends up being charged. What must the sign of the charge on the silk be for the electric force (applied by the uniform field) to be directed up on the silk (and the spider).

[ ] positive [✓] negative

[2 points] (c) Determine the magnitude of the charge on the silk if the upward electric force exactly balances the downward gravitational force acting on the spider, with mass of 1.00 milligrams, 10^{-6} kg.



$F_E = F_g$ $\quad qE = mg$ $\quad q = \frac{mg}{E} = \frac{(10^{-6})(10)}{100} = \frac{(10)^{-5}}{10^2} = 10^{-7}$

$E = \Delta V/d = 5V/0.05m = 100 V/m$

$|q| =$ 10^{-7} C

[2 points] (d) If the charge were 10% larger than the value needed for the forces to balance, what would be the magnitude of the spider's acceleration?

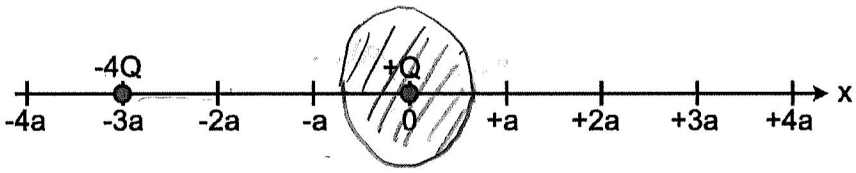
$F = ma$ $\quad \frac{qE - mg}{m} = a$ $\quad a = \frac{(1.1 \times 10^{-7})(100)}{10^{-6}} - 10$

$F_E - F_g = ma$ $\quad a = \frac{qE}{m} - g$ $\quad = 11 - 10 = 1$

$|a| =$ 1 m/s^2

PROBLEM 3 – 6 points

Two charged particles are placed on the x-axis, as shown. Only these two particles contribute to the electric field and electric potential. Neglect any gravitational interactions.



[2 points] (a) Determine a location on the x-axis (a finite distance from the charged particles) where the **electric field is zero**. located at right of +Q charge

$E = \frac{(-4)Qk}{(3a+r)^2} + \frac{Qk}{r^2} = 0 \rightarrow \frac{4}{(3a+r)^2} = \frac{1}{r^2} \rightarrow 4r^2 = r^2 + 6ar + 9a^2$ $\quad r^2 - 2ar - 3a^2 = 0$

$3r^2 - 6ar - 9a^2 = 0$ $\quad (r-3a)(r+a) = 0$

$r = 3a$, $-a$ ∈ $-a$ is impossible

$x =$ 3 a

[2 points] (b) Determine a location on the x-axis (a finite distance from the charged particles) where the **electric potential is zero**. If there is more than one location, you only need to determine one.

$V = 0 = \frac{-4Qk}{r} + \frac{Qk}{3a-r}$ $\quad$ 4 in between -4Q and +Q

$\frac{4Qk}{r} = \frac{Qk}{3a-r}$ $\quad 12a - 4r = r$ $\quad 12a = 5r$

$r = 12/5 a = 2.4a$ right from $-4Q \Rightarrow -3a + 2.4a = -0.6a$

$x =$ −0.6 a

[1 point] (c) On the figure above, draw a rough sketch of the $V = 0$ equipotential on the $x - y$ plane as viewed from directly above. Also indicate where $V > 0$ by lightly shading in that region.

[1 point] (d) Which charge feels a larger magnitude force because of its interaction with the other?

[ ] the $-4Q$ charge [ ] the $+Q$ charge [✓] they feel forces of equal magnitude