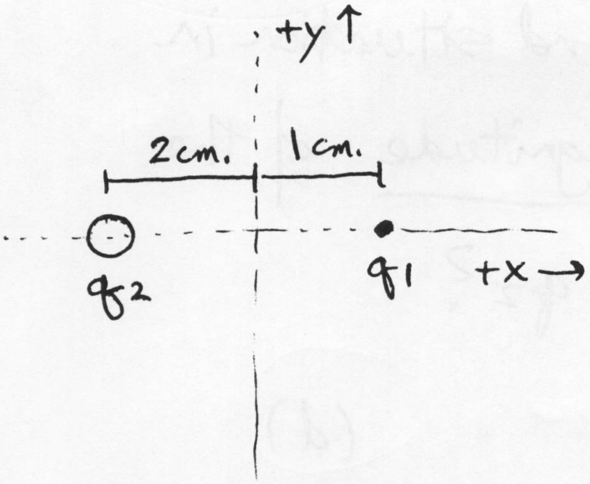
PHY 1B(b) Quiz #1 Solutions

Problem #1



$q_1 = -2 \times 10^{-9}$ Coulombs

$q_2 = +4 \times 10^{-9}$ Coulombs

What direction is the force on q_1, from charge q_2?

(a) +x

[✓ (b) −x]

(c) no force

Answer: Opposite charges attract, and therefore, the force on q_1 would be in the −x direction.

Problem #2

Referring to the diagram and situation in Problem #1, what is the magnitude of the force on q_1, from charge q_2?

(a) 0 N

[✓ (b) 8×10^{-5} N]

(c) 2×10^{-6} N

(d) 8×10^{-9} N

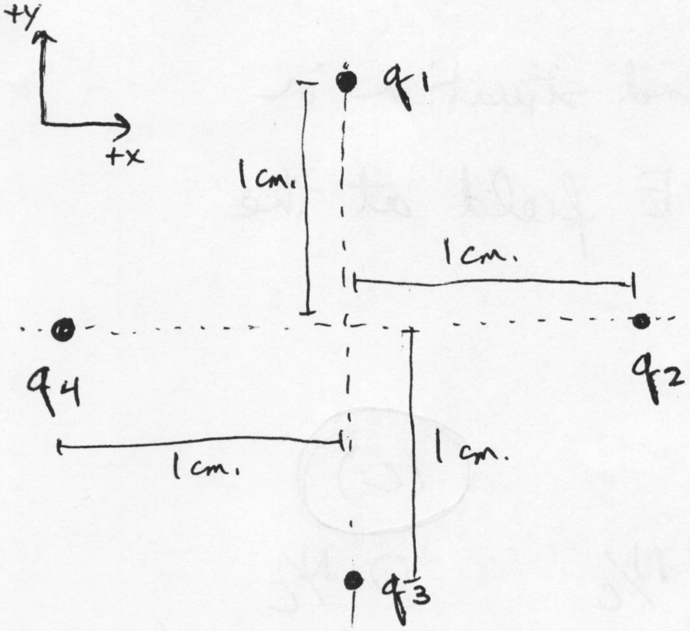
Answer:

$$|\vec{F}| = \frac{k_e|q_1||q_2|}{r^2}$$

$$= \frac{\left(8.99\times10^{9}\ \frac{Nm^2}{C^2}\right)\left(2\times10^{-9}\ C\right)\left(4\times10^{-9}\ C\right)}{\left(3\times10^{-2}\ m\right)^2}$$

$$\approx \boxed{8\times10^{-5}\ N}$$

Problem #3



$q_1 = -0.5 \times 10^{-9}$ C

$q_2 = +2.0 \times 10^{-9}$ C

$q_3 = -0.5 \times 10^{-9}$ C

$q_4 = +2.0 \times 10^{-9}$ C

Which direction is the net force on q_2?

[✓ (a)] +x

(b) diagonal

(c) +y

(d) −y

Answer: Charges q_1 and q_3 are equidistant from q_2 and exert equal and opposite forces, therefore cancelling each other's force contribution. The net force comes from q_4, which repels q_2 in the +x direction.

Problem #4

Referring to the diagram and situation in Problem #3, what is the E field at the origin (x=0, y=0)?

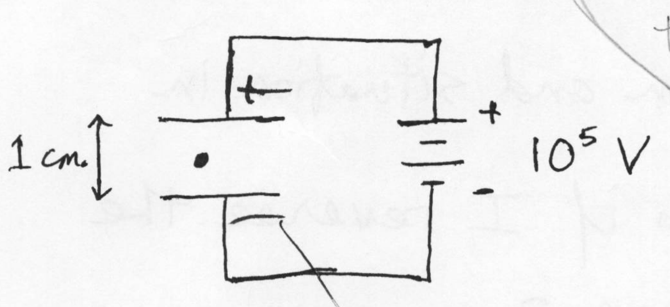
(a)	(b)	[✓ (c)]
$+3.15 \times 10^2$ N/C	-3.15×10^2 N/C	0 N/C

Answer:

q_2 and q_4 are equidistant from the origin and create electric fields that are equal and opposite. The same applys with q_1 and q_3. Therefore, the net E-field at the origin is 0 N/C.

Problem #5

Note: The correct answer was not one of the choices. Therefore, this question was not graded. Sorry!



~~You are asked to measure the charge on an oil drop placed in the capacitor shown above. If you are able to deposit 1 electron on the oil drop, and the drop doesn't move, what is the mass of the drop?~~

~~(a) the drop can not be motionless~~

~~(b) 1.63×10^{-11} kg.~~

~~(c) 1.63×10^{-17} kg.~~

~~(d) 3.26×10^{-17} kg.~~

Answer: $V = Ed \Rightarrow E = \frac{V}{d} = \frac{10^5\,V}{1\times10^{-2}\,m} = 10^7\ V/m$

Forces on the electron (oil drop) $\Rightarrow$ $\uparrow F_{elec.}$ $\bullet$ $\downarrow F_{gravitational}$ $\qquad \Sigma F_{Net} = 0$

$\Rightarrow F_g = F_e \Rightarrow mg = qE \Rightarrow m = \frac{qE}{g} = \frac{(1.6\times10^{-19}\,C)(10^7\,V/m)}{9.8\,m/s^2}$

$\Rightarrow \boxed{m = 1.63\times10^{-13}\ kg.}$

Problem #6

Referring to the diagram and situation in Problem #5, what happens if I reverse the voltage on the power supply?

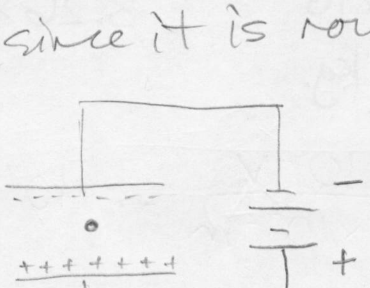
(a) The oil drop moves upward

[✓ (b) The oil drop moves downward]

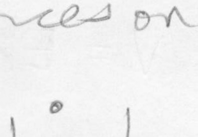
(c) The oil drop doesn't move.

Answer:

When I switch the voltage on the power supply, the electron is not attracted the bottom plate (since it is now positively charged).



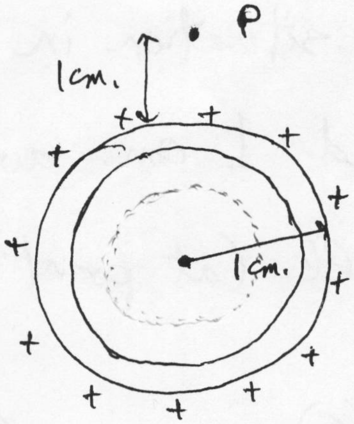
Therfore, the forces on the drop are



The net force causes the oil drop to move

$\boxed{\text{downward.}}$

Problem #7



I have a hollow metallic ball (radius = 1 cm.) that I have charged with positive charge $Q = +2\times10^{-9}$ C. As you know by now, the charge will redistribute itself evenly on the surface of the ball. What is the E field inside the ball at the center?

[✓ (a) zero N/C]

(b) 1.8×10^{5} N/C

(c) -1.8×10^{5} N/C

Answer: Draw a Gaussian surface inside the ball as shown above. No charge is enclosed! According to Gauss's law, $E = \frac{Q_{net}}{A\varepsilon_0}$, the E-field is therefore 0. N/C.

Problem #8

Referring to the diagram and situation in Problem #7, what is the E field 1 cm. away from the outside edge of the ball (at point P)?

[✓ (a)] $+4.50\times10^4$ N/C

(b) 1.8×10^5 N/C

(c) -4.50×10^4 N/C

(d) -1.8×10^5 N/C

Answer:

Gauss's law: $EA = \frac{Q_{net}}{\varepsilon_0} \Rightarrow E = \frac{Q_{net}}{A\,\varepsilon_0}$

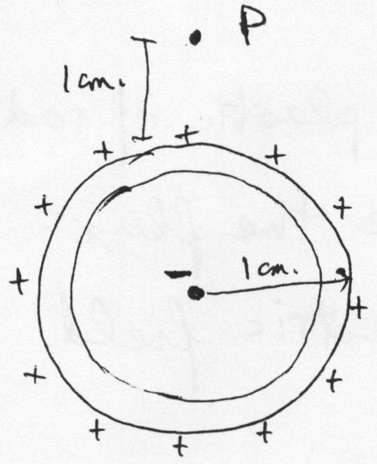
The surface area of my Gaussian surface is $4\pi r^2$. The radius of the surface is 2 cm.

$$\Rightarrow E = \frac{+2\times10^{-9}C}{4\pi(2\times10^{-2}m)^2\cdot\varepsilon_0} \qquad k_e = \frac{1}{4\pi\varepsilon_0}$$

$$\Rightarrow E = \frac{(8.99\times10^9\ N\cdot m^2/C^2)(2\times10^{-9}C)}{(2\times10^{-2}m)^2}$$

$= +4.5\times10^4$ N/C (the sign is positive because the direction of the electric field is outward.)

Problem #9



Q on ball $= +2\times10^{-9}\,C$

Q at center $= -1\times10^{-9}\,C$

If I now put a negative charge (in addition the positive charge on the surface of the ball) at the center of the ball with $Q = -1\times10^{-9}\,C$, what is the E field at point P?

(a) 0 N/C

~~(b) $+9.0\times10^{4}$ N/C~~

(c) -2.25×10^{4} N/C

[✓ (d) $+2.25\times10^{4}$ N/C]

at point P
↓ Answer!

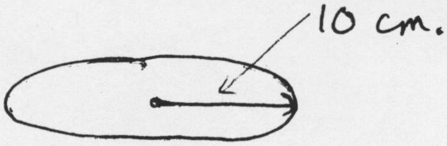
$Q_{net} = +2.0\times10^{-9}\,C + (-1\times10^{-9}\,C) = +1\times10^{-9}\,C$

$$\Rightarrow E = \frac{Q_{net}}{A\varepsilon_0} = \frac{Q_{net}}{4\pi r^2\varepsilon_0} = \frac{k_e Q_{net}}{r^2} = \frac{k_e(+1\times10^{-9}\,C)}{(2\times10^{-2}\,m)^2}$$

$$= \boxed{+2.25\times10^{4}\,N/C}$$

(positive again since electric field points outward)

Problem #10



I have a circular sheet of plastic of radius 10 cm. and I want to determine the flux through that sheet from an electric field generated in a thunderstorm.

Suppose the field is generated by a positive charge in the clouds, and the end of the field is at the ground. If I put the plastic sheet flat on a table, what is the flux of an electric field of 100,000 $\text{Volts}/_{\text{kilometer}}$ through the sheet?

(a) 0 V·m

(b) 3.14×10^3 V·m

[✓ (c)] 3.14 V·m

(d) 10^5 V·m.

See next page →

Problem #11

Referring to the situation in Problem #10, what is the flux through the sheet if I now rotate it through 45° along an axis parallel to the Earth?

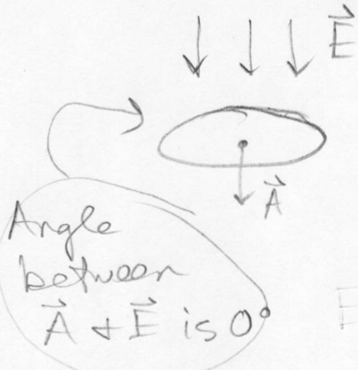
(a) 0 Vm

(b) 10^3 V·m

(c) 0.707 Vm.

[✓ (d)] 2.22 Vm

Problem #10 Answer:



Flux: $\phi = EA\cos\theta$

$$A = \pi r^2 = \pi(.1\,m)^2 = 3.14\times10^{-2}\,m^2$$

$$\Rightarrow \phi = (100{,}000\ V/km)(3.14\times10^{-2}\,m^2)\cos(0°)$$
$$= (100\ V/m)(3.14\times10^{-2}\,m^2) = \boxed{3.14\ V\cdot m}$$

Problem #11 Answer:

$$\phi = EA\cos45° = (3.14\ V\cdot m)\cos(45°) = \boxed{2.22\ V\cdot m}$$