Exhibit D:
JERICO MATIAS CRUZ'S
EXAMS, LABORATORY REPORTS,
& CENGAGE ORDER ON OCTOBER 3, 2021

Physics 236 **Test One** PROF. SCHMITT

Name: JERICO M. CRUZ

SUBMITTED: OCTOBER 3, 2024

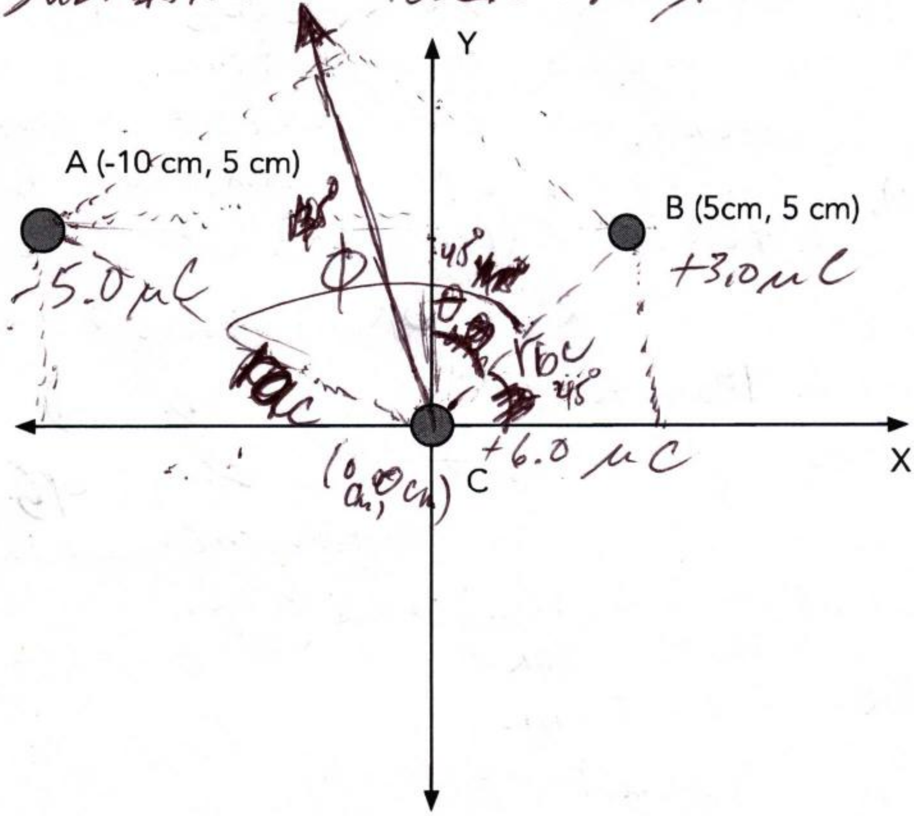


Figure 1

1) (20 pts.) In figure 1, charge "A" is -5.0 μC, charge "B" is +3.0 μC and charge "C" is +6.0 μC. Find the force (magnitude and direction) on charge "C".

SEE PAGE 2 OF 6 FOR CONTINUATION

(a) SUPPOSE NEWTON'S SECOND LAW OF MOTION APPLIES TO THIS QUESTION, FORCE = MASS X ACCELERATION = $m \times a = m \times dv/dt$, WHERE dv = DERIVATIVE OF VELOCITY, dt = derivative OF TIME. ~~GIVEN THAT~~ IF $(DV/DT) = 0$, THEN $F = m \times 0 = 0$, WHEN DERIVATIVE OF VELOCITY IS ZERO. LET $F_c = m_a \times a_a = m_a \times (dv_a/dt_a)$; $F_b = m_b \times a_b = m_b \times (dv_b/dt_b)$.

SO, $\Sigma F_c = F_a + F_b$, THEREFORE, $\Sigma F_c = F_a + F_b$.

(b) SUPPOSE $\Sigma F_c = F_a + F_b$: GIVEN THAT CHARGE "A" IS $-5.0\ \mu C$, CHARGE "B" IS $+3.0\ \mu C$ AND CHARGE "C" IS $+6.0\ \mu C$; at point charge A = (-10 cm, 5 cm), at point charge B = (5 cm, 5 cm), and point charge C = (0 cm, 0 cm).

~~[scribbled out]~~ LET $\sum F_c = (q_a - q_c) + (q_b - q_c)$. SO, $F_a = (q_a - q_c)$; $F_b = (q_b - q_c)$, where q_a, q_b and q_c are point of CHARGES. THEREFORE; $\sum F_c = F_a + F_b$

(c) SUPPOSE $F_a = F_a$. Let $F_c = F_a = F_b = k \times [(q_b \times q_a)/r^2]$, where F IS ELECTROSTATIC FORCE, K = Coulomb's constant or electrostatics Constant, q_b, q_a = CHARGES, AND R = distance OF SEPARATION BETWEEN CHARGES C AND A. GIVEN A = +5.0 μC at (−10cm, 5cm), B = +3.0 μC at (5cm, 5cm), and C = +6.0 μC at (0cm, 0cm). LET $F_c = F_a = F_b = k \times [(q_b \times q_a)/r^2]$ SO, $F_c = k \times [(q_b \times q_a)$, GIVEN r = SLOPE (q_b, q_a) OR TAN θ, OR TAN φ. THEREFORE, $F_c = k \times [(q_b \times q_a)/r^2]$, as slope OF $R = [(5-5)/(5-(-10))] = 0$; θ = 45°; φ = 45°

(d) FOR r_{bc}: let tan θ = o/a, using trigonometric function. Given θ = 45 CHARGE B = +3.0 μC at (5cm, 5cm); and o = opposite of a triangle and a adjacent of a triangle. So tan θ = o/a => a = o/tan θ; THEREFORE, a = 5/tan 45° = 5Cm.

FOR r_{ac}: let tan φ = o/a, using trigonometric function. Given φ = 45° CHARGE A = −5 μC at (−10cm, 5cm); and a = adjacent of the TRIANGLE. and o = opposite of triangle. SO, tan φ = o/a => a = o/tan θ. THEREFORE: a = −10/tan 45° = −10 cm.

(e) FOR F_{ac}: let $F_c = F_a = F_b = k \times [(q_a \times q_c)/r_{ac}^2]$, where $k = 9 \times 10^9\ N \cdot m^2 \cdot C^{-2}$; q_a, q_c = charges, and r = distance between CHARGES A AND C.

So, $F_{ac} = (9 \times 10^9\ N \cdot m^2 \cdot C^{-2}) \times [((-5.0 \times 10^{-6}\ C \times) \times (+6.0 \times 10^{-6}\ C))/ -10^2]$. therefore, $F_{ac} = 27\ N$

FOR F_{bc} = Let $F_c = F_a = F_b = k \times [(q_b \times q_c)/r_{bc}^2]$, where $9 \times 10^9\ N \cdot m^2 \cdot C^{-2}$, q_b, q_c = charges, and r = distance between charges b and c. So,

$F_{bc} = (9 \times 10^9\ N \cdot m^2 C^{-2}) \times [((+3.0 \times 10^{-6}\ C) \times (+6.0 \times 10^{-6}\ C)/0.05^2] =$ Therefore, $F_{bc} = 64.8\ N$

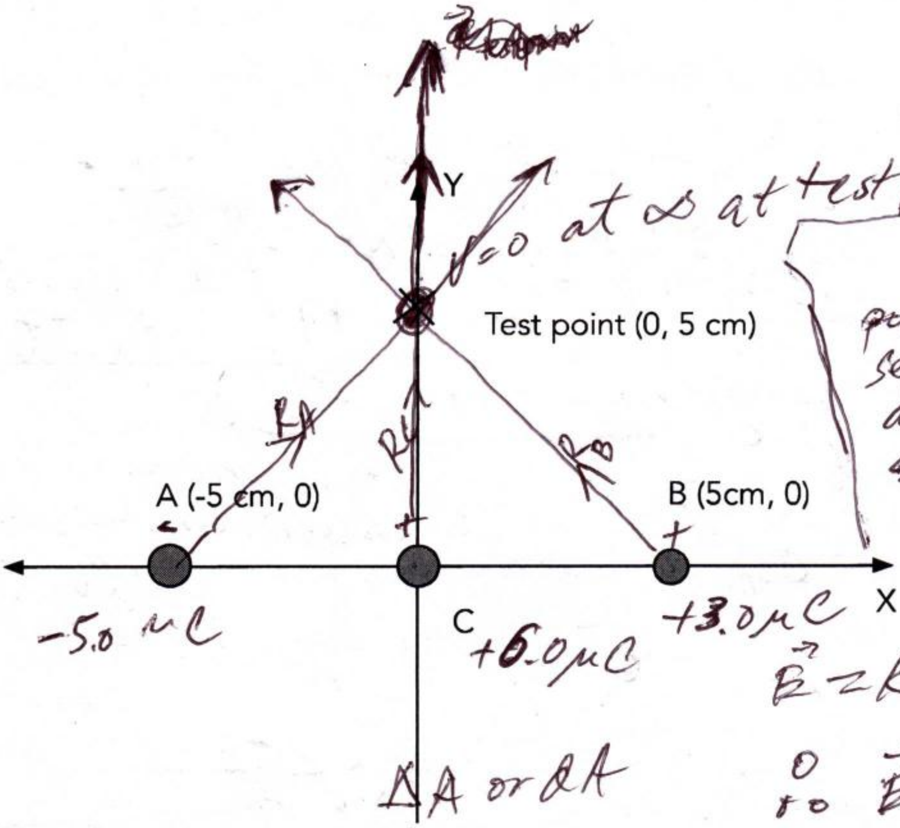
(f) For F_{ac}: $F_{acx} = (27\ N) \cos 45° = 19\ N$; $F_{acy} = (27\ N) \sin 45° = 19\ N$

For F_{bc}: $F_{bcx} = (64.8\ N) \cos 45° = 45.8205\ N$; $F_{bcy} = (64.8\ N) \sin 45° = 45.8205\ N$

(g) $F_{cx} = F_{acx} + F_{bcx} = 19\ N + 45.8205\ N = 64.8205\ N$

$F_{cy} = F_{acy} + F_{bcy} = 19\ N + 45.8205\ N = 64.8205\ N$

(h) $F_c = (64.82\hat{i} + 64.82\hat{j})\ N$



(a) Suppose $\Delta\vec{E} = k\left(\frac{\Delta q}{r^2}\right)\hat{r}$, where $\Delta\vec{E}$ = change in electric field, Δq = change in point of charge, r = distance separation / change of point charge, and $\hat{r}$ = direction of the specific charge point. Let $E = k\sum_i \frac{\Delta q_i}{r_i^2}\hat{r}_i$, where $\sum_i$ = sum of i, so, $\vec{E} = k \lim_{\Delta q_i \to 0} \sum \frac{\Delta q_i}{r_i^2}\hat{r}_i$: so $\vec{E} = k\int \frac{dq}{r^2}\hat{r}$.

Figure 2

2) (30 pts.) In figure 2, charge "A" is -5.0 μC, charge "B" is +3.0 μC and charge "C" is +6.0 μC. Find the electric field and electric potential (assume V is zero at infinity) at the test point.

SEE PAGE 2 OF 6 FOR CONTINUATION

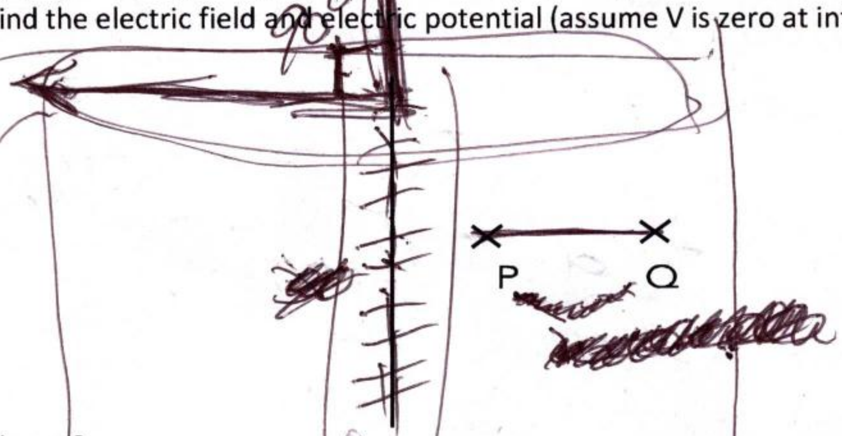
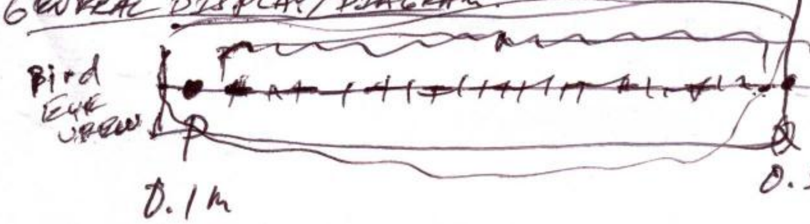


Figure 3

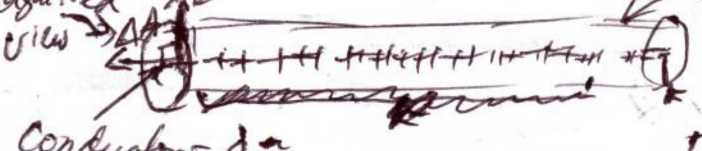
3) (20 pts.) A long wire (assume infinite) has a charge per unit length of λ. Show how a Guassian surface can be used to find the electric field a distance r from the wire. Show how you would find the potential difference between points P and Q. If λ = +6.0 μC/m and P is at 0.1 m and Q is at 0.3 m then what is the potential difference between them? SEE

GENERAL DISPLAY / DIAGRAM:



$\lambda_{WIRE} = \lambda = +6\ \mu C/m$

(a) SHOW HOW A GAUSSIAN SURFACE CAN BE USED TO FIND THE ELECTRIC FIELD A DISTANCE (r) FROM THE WIRE.



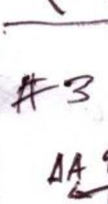
$\vec{E}$ = ELECTRIC FIELD
ΔA = change in Area
r = distance from the wire
$q = \lambda$ = charge per unit length

#2 (b) Let $\Sigma \vec{E}_{tp} = \vec{E}_a + \vec{E}_b + \vec{E}_c$, where $\vec{E}_{tp}$ = Electric field at test point, $\vec{E}_a$ = electric field at point charge A, $\vec{E}_b$ = electric field at point charge B, and $\vec{E}_c$ = electric charge at point charge C. So, $\Sigma \vec{E}_{tp} = k_a \int_{tp}^{a} \frac{dq_a}{r_a^2}\hat{r}_a + k_b \int_{tp}^{b} \frac{dq_b}{r_b^2}\hat{r}_b + k_c \int_{tp}^{c} \frac{dq_c}{r_c^2}$. Therefore $\Sigma \vec{E}_{tp} = \left[(9\times10^{9} N\cdot m^2\cdot C^{-2}) \times \left(\frac{-5\times10^{-6}C}{-0.05^2}\right)\hat{r}_a\right] + \left[(9\times10^{9} N\cdot m^2\cdot C^{-2}) \times \left(\frac{3.0\times10^{-6}C}{0.05^2}\right)\hat{r}_b\right] + \left[(9\times10^{9} N\cdot m^2\cdot C^{-2}) \times \left(\frac{6\times10^{-6}C}{0.05^2}\right)\hat{r}_c\right] = -1.8\times10^{7} N + 1.08\times10^{7} N + 2.16\times10^{7} = \boxed{1.44\times10^{7} N}$. Therefore, $\vec{E}_{tp} = 1.44\times10^{7} N$.

(c) Suppose $V_c - V_{tp} = -kq\int_{tp}^{c}\frac{dr}{r^2}$, where V_c = volts of direction of point charge C, V_{tp} = volts of direction of point charge testing point, k = Coulomb's constant, dr = derivative of direction or line segment $\overline{Ctp}$, q = point charge C, and r = distance of a point charge C. Let $V_c - V_{tp} = kq\left[\frac{1}{r_c} - \frac{1}{r_{tp}}\right]$. So, $V = k\frac{q}{r}$ where $V_{tp} = 0$ at ∞. $\therefore V = k(q/r)$.

(d) Let $V = k\sum_i \frac{q_i}{r_i}$, where k = number, $\sum_i$ = sum of $\frac{q_i}{r_i}$, q_i = number of point charges and r_i = number of distance(s) of point charges. So, $V_{tp} = k\sum\left(\frac{-5\times10^{-6}C}{.05\,m}\right) + \left(\frac{3\times10^{-6}C}{.05\,m}\right) + \left(\frac{6\times10^{-6}C}{.05\,m}\right) = (9\times10^{9} N\cdot m^2\cdot C^{-2})(1.81\times10^{-4} C/m) \therefore \boxed{1.629\times10^{6} V = V_{tp}}$

#3 I have to magnify the view of the Gaussian surface into cylindrical shape of the wire

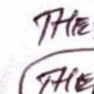


Suppose $E = \frac{k\times q}{r^2}$, where E = electric field, k = Coulomb's constant, q = charge, and r = displacement of the charge. Given that $E \times \Delta A = E \times \Delta A$, where ΔA = change in the area of the surface. Let $\Phi_E = \int \vec{E}\cdot d\vec{A}\cos 90°$, where Φ_E = electric flux, dA = derivative of the area surface. So, $\Phi_E = \int_{surface} E \times dA \cos 0 = E\int_{surface} dA = \frac{k\times q}{r^2}(2\pi r h)$, where $2\pi rh$ is the surface area of the cylinder.

Therefore, $\Phi_E = \frac{q}{\varepsilon_0}$, where ε_0 = electric constant.

Therefore, $E\times 2\pi r h = \frac{\lambda h}{\varepsilon_0} \Rightarrow E = \frac{\lambda}{2\pi\varepsilon_0 r}$

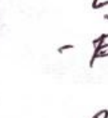
(b) Show how would you find the potential difference between points P and Q.



Suppose $\Delta V = \frac{\Delta U_E}{q}$, given that potential electric points P and Q have uniform electric field; where ΔV = change in volts or voltage; ΔU_E = change in uniform electric field; and q = charge. Let $\Delta V = -\int_P^Q \vec{E}\,d\vec{s}$, where ds = derivative of the surface. So, $\Delta V = -\vec{E}\times\int_P^Q d\vec{s} = -\vec{E}\cdot\vec{s}$. Therefore, $\Delta U_E = q\Delta V = -q\vec{E}\times\vec{s}$. Therefore, points P and Q are at the same electrical potential.

(c) If $\lambda = +6.0\,\mu C/m$ and P is at 0.1 m and Q is at 0.3 m then what is the potential difference between them?

The potential difference is:



Using the equation on (b): $\Delta U_E = q\Delta V \Rightarrow \Delta U_{EQ} - U_{EP} = q(U_Q - U_P) \Rightarrow U_E = q(0.3m - 0.1m)$, where $q = \lambda = +6.0\,\mu C/m$. Therefore, $U_E = +6.0\,\mu C/m\,(0.2\,m) = 1.2\,\mu C \therefore U_E = 1.2\,\mu C$

A = AREA OF THE ~~...~~ REGION
ΔAi = change in VECTOR A
A⊥ = AREA OF A
a⊥ = AREA OF THE SIDE OF SQUARE
$\vec{E}$ = ELECTRIC FIELD
θ = ELECTRIC FIELD MAKES AN ANGLE
Em = A of ELECTRIC FIELD
Φe = ElectricFlux
See explanation on PAGE 6 of 6.

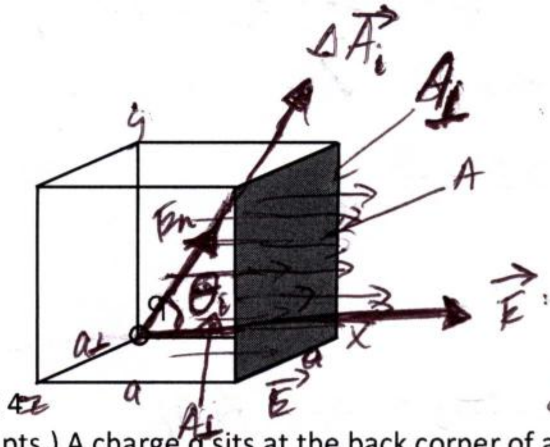


Figure 4

4) (10 pts.) A charge q sits at the back corner of a block (as shown). What is the flux of **E** through the blue region? (DONE)

d = displacement

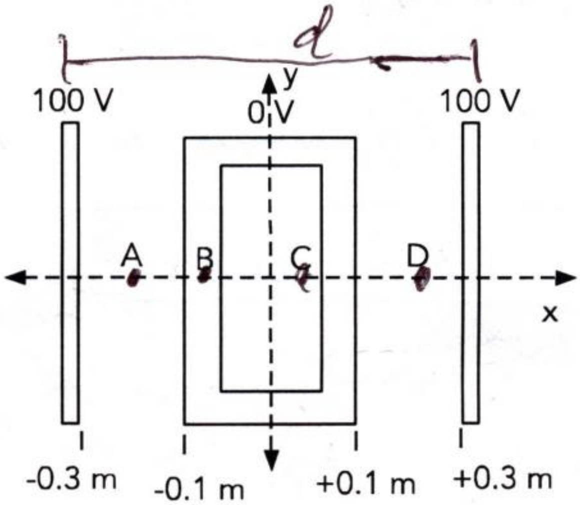


Figure 5

5) (20 pts.) Two parallel plates at 100 volts have a hollow metal box (as shown) in between the plates set at 0 volts. Describe using words or equations the electric field and the electric potential in regions A, B, C and D which are along the x-axis the assumed far from the edges of box and plates. BY DEFINITION, THE ELECTRIC FIELD IS A MEASURE OF THE RATE OF CHANGE OF THE ELECTRIC POTENTIAL WITH RESPECT TO POSITION. IN FIGURES 5, THE SEPARATION BETWEE THE TWO PARALLEL PLATES AT 100 VOLTS IS DISPLACEMENT = 0.6 METER, ASSUMING THE ELECTRIC FIELD BETWEEN TWO PARALLEL PLATES AT 100 VOLTS TO BE UNIFORM. THIS ASSUMPTION IS REASONABLE IF EACH PLATE SEPARATION IS SMALL RELATIVE RELATIVE TO THE PLATE DIMENSIONS, SIZE, AND LASTLY, NO CONSIDERATION MADE ON THE LOCATIONS NEAR THE PLATE EDGES. IN ADDITION, THE ELECTRIC POTENTIAL REGIONS A, B, C, AND D WHICH ARE ALONG THE X-AXIS FAR FROM THE EDGES OF BOX AND PLATES.

SEE CONTINUATION PAGE 6 of 6.

#4 Suppose $A = a \times a_\perp = a^2; a_\perp = a\cos\theta$; $A_\perp = a \times a_\perp = a \cdot a\cos\theta$.
GIVEN THAT AREA OF A SQUARE IS THE PRODUCT OF BOTH SIDES
LET $\Phi_E = EA_\perp$ AND $\Phi_E = EA\cos\theta$
SO, $\Phi_E = (E\cos\theta)A = E_n A$
THEREFORE, $\Phi_{E,i} = E_i \times \Delta A_i \cos\theta_i = E_i \times \Delta A_i$
THEREFORE, $\Phi_E \approx E_i \times \Delta A_i$
OR
THEREFORE, $\Phi_E \equiv \int_{A_{SURFACE}} E \times dA$, where dA = derivative of A.

$\therefore$ Φ_E through A = Positive OR SLIGHTLY CLOSE TO ZERO.

#5 (A) Suppose $W = F \times ds = qE \cdot ds$, where W = work, F = force
q = charge, E = electric field, and ds = derivative of surface of a plate. Let $W = -\Delta U_E$, where ΔU_E = change in uniform electric field. SO, $dU_E = -W = -qE \times ds$, ~~THEREFORE~~, where dU_E = derivative of uniform electric field of each plate.
THEREFORE, $\Delta U_E = -q \int_A^D \vec{E} \times d\vec{s}$, where A, B, C, AND D ARE ELECTRIC POTENTIAL REGIONS. THEREFORE, $V = \frac{U_E}{q}$, where V = volt or voltage.

(B) Suppose $V_D - V_A = \Delta V = -\int_A^D E \times d\vec{s}$, where ΔV = CHANGE IN VOLT, E = ELECTRIC FIELD, AND A, B, C, and D ARE ELECTRIC POTENTIAL REGIONS, OF EACH PLATES AT 100 VOLTS. GIVEN THAT $\Delta V = -\int_A^D E \times ds\,(\cos\theta) = -\int_A^D E \times ds$. LET $\Delta V = -E\int_A^D ds$. SO, $\Delta V = -Ed$. THEREFORE, $\Delta U_E = q\Delta V = -qEd$, where ΔU_E = CHANGE IN UNIFORM ELECTRIC FIELD. THEREFORE, POINTS A, B, C AND D ARE AT THE SAME ELECTRIC POTENTIAL

Physics 236 Test Two

Name: JERICO MATIAS CRUZ

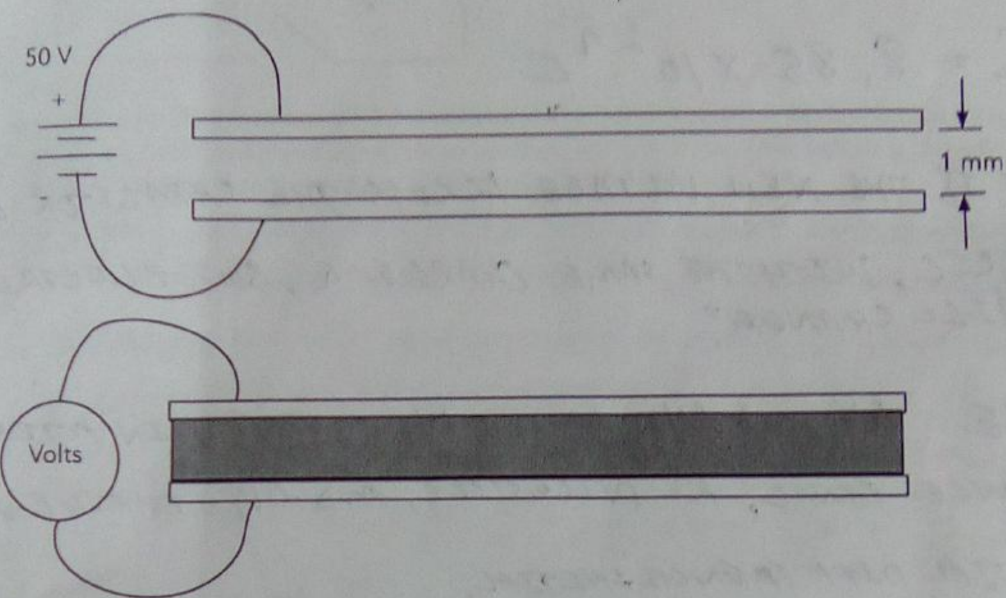


Figure 1

1) (20 pts.) Two plates 1 m^2 each have a 1 mm gap between them. What is the capacitance? The capacitor is fully charge to 50 V then remove from the power supply, a dielectric with $\kappa = 2.5$ is placed between the plates. What is the new voltage across the capacitor with the dielectric, remember charge q is still the same, but electric field will change?

(a) WHAT IS THE CAPACITANCE?

BY DEFINITION, CAPACITANCE (C), OF A CAPACITOR IS DEFINED AS THE RATIO OF THE MAGNITUDE OF THE CHARGE (Q) ON EITHER CONDUCTOR TO THE MAGNITUDE OF THE POTENTIAL DIFFERENCE (ΔV) BETWEEN THE CONDUCTORS: ~~IN ADDITION~~, $C = Q/\Delta V$. IN ADDITION, C, Q, AND ΔV ARE ALWAYS EXPRESSED AS POSITIVE QUANTITIES.

SUPPOSE $C = Q/\Delta V$, GIVEN THAT ~~TWO PLATES 1 m~~^{2} THE EXPRESSION FOR THE CAPACITANCE OF A PARALLEL-PLATE, $C = \frac{\varepsilon_0 A}{d}$, WHERE ε_0 = ELECTRIC CONSTANT, A = AREA OF EACH PARALLEL PLATE, AND d = DISTANCE BETWEEN TWO PARALLEL-PLATE CAPACITOR. LET $C = \frac{\varepsilon_0 A}{d}$, GIVEN THAT $A = 1\ m^2$, $d = 1\ mm$, and $\varepsilon_0 = 8.85 \times 10^{-12}\ C^2/N \cdot m^2$. (SEE CONTINUATION ON PAGE 2 of 8

$$SO,\ C = \frac{\varepsilon_0 A}{d} = \frac{(8.85 \times 10^{-12}\ C^2/N \cdot m^2)(1\ m^2)}{(1.00 \times 10^{-3}\ m)} =$$

$$= 8.85 \times 10^{-9}\ F.$$

$$\therefore\ C = 8.85 \times 10^{-9}\ F$$

(b) WHAT IS THE NEW VOLTAGE ACROSS THE CAPACITOR WITH DIELECTRIC, WITH THE SAME CHARGE Q, BUT ELECTRIC FIELD WILL CHANGE?

SUPPOSE $\Delta V_f = k \Delta V_i$, WHERE ΔV_f = CHANGE IN POTENTIAL DIFFENCE FINAL, K = DIELECTRIC, AND ΔV_i = CHANGE IN POTENTIAL DIFFERENCE INITIAL.

LET $\Delta V_f = k \Delta V_i$, WHERE $k = 2.5$, AND $\Delta V_i = 50V$.

$$SO,\ \Delta V_f = (2.5)(50\ V) = 1.25 \times 10^2\ V$$

$\therefore\ \Delta V_f = 1.25 \times 10^2\ V$, WHICH IS THE NEW VOLTAGE ACROSS THE CAPACITOR.

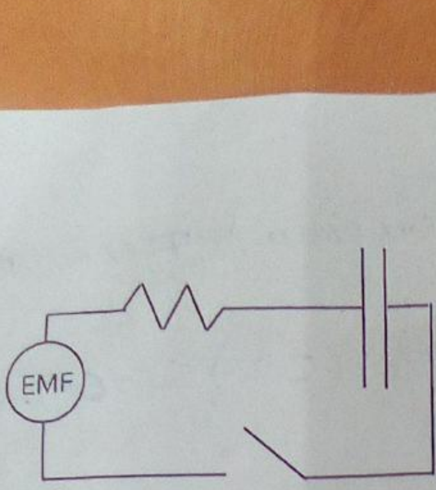


Figure 2

2) (20 pts.) An RC circuit has a 5.5 kΩ resistor and a 8.0 μF capacitor in series, how long will it take for the fully discharged capacitor to be charged to 95% once the switch is closed? ________
How long would it if a second 8.0 μF capacitor is added in series? ________

(a) HOW LONG WILL IT TAKE FOR THE FULLY DISCHARGED CAPACITOR TO BE CHARGED TO 95% ONCE THE SWITCH IS CLOSED?

SUPPOSE $\tau = RC$, GIVEN THAT $R = 5.5\ k\Omega$ and $C = 8.0\ \mu F$ IN A SERIES. LET $RC = \tau$, WHERE R = RESISTOR, C = CAPACITOR, AND τ = ~~TIME INTERVAL~~ TIME CONSTANT. LET $\tau = RC = (5.50 \times 10^{3}\ \Omega)(8.00 \times 10^{-6}\ F) = 0.044\ s$. let $dq/dt = \frac{C\mathcal{E}}{RC} - \frac{q}{RC} = -\frac{q - C\mathcal{E}}{RC} \rightarrow$ $\frac{dq}{q - C\mathcal{E}} = -\frac{1}{RC}dt$. Let $\int_0^q \frac{dq}{q - C\mathcal{E}} = -\frac{1}{RC}\int_0^t dt$, WHERE $q = 0$ At $t = 0$.

SO, $\ln\left(\frac{q - C\mathcal{E}}{-C\mathcal{E}}\right) = -\frac{t}{RC}$.

(CONTINUATION PAGE 4 OF 8

3) (10 pts) A particle with a charge of +9.0 μC is going from left to right at 5.5×10^5 m/s. There is a 2 T field going into the paper. Using $F = qvB\sin\theta$ find the magnitude and direction of the force.

Suppose $\vec{F}_B = q\vec{v}\vec{B}\sin\theta$, WHERE $\vec{F}_B$ = magnitude OF THE MAGNETIC FORCE ON A CHARGED PARTICLE, q = CHARGE OF A PARTICLE, $\vec{v}$ = VELOCITY OF A MOVING PARTICLE, ~~AND~~ $\vec{B}$ = MAGNETIC FIELD, AND θ = SMALLER ANGLE BETWEEN $\vec{v}$ AND $\vec{B}$. LET $\vec{F}_B = q\vec{v}\vec{B}$, WHERE $q = +9.0\ \mu C$, $v = 5.5 \times 10^5\ m/s$, AND $\vec{B} = 2T$. SO, $\vec{F}_B = (+9.00 \times 10^{-6}\ C)(5.5 \times 10^{5}\ m/s)(2T) = +9.9\ N$, WHICH IS A MAGNETIC FORCE ON A CHARGED PARTICLE IN STATIONARY. LET $\sin\theta = \vec{F}_B / q\vec{v}\vec{B} = +9.9N / (+9.00 \times 10^{-6}\ C)(5.5 \times 10^{5}\ m/s)(2T) = 1$ OR

(CONTINUATION PAGE 4 OF 8

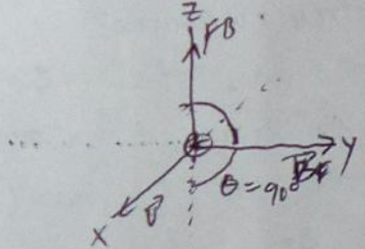
#3 SIN (90°) = 1, WHICH $\theta = 90°$

Let $\vec{F}_B = q\vec{v}\vec{B}\sin\theta$ FOR MOVING CHARGED PARTICLE IN MAGNETIC FIELD.

So, $\vec{F}_B = (9.00 \times 10^{-6}\,C)(5.5 \times 10^{5}\,m/s)(2T)\,\mathrm{SIN}\,90 =$

$= 9.9\,N.$

$\therefore$ $\vec{F}_B = 9.9\,N$, WHICH IS THE MAGNITUDE OF THE MAGNETIC FORCE ON A CHARGED PARTICLE.



$\therefore$ DIRECTION OF F_B ACTING ON THE CHARGED PARTICLE IS IN POSITIVE Z WHEN $\vec{v}$ AND $\vec{B}$ LIE IN THE XY PLANE.

#2 $\therefore$ $q(t) = C\varepsilon\left(1 - e^{-t/RC}\right) = Q_{max}\left(1 - e^{-t/RC}\right)$, WHERE e = BASE OF THE NATURAL LOGARITHM AND $Q_{max} = C\varepsilon$. AT TIME = 0, ~~CONSTANT,~~ $q(0) = Q_{max} = 0$.

$\therefore$ $q(0.044) = \left(\frac{1 - 0.95Q_{max}}{Q_{max}}\right)\left(1 - e^{-t/RC}\right)$, WHERE $RC = 0.044\,s$.

$q(0.44) = \left(\frac{1 - 0.95Q_{max}}{Q_{max}}\right)(.0.632) = 0 \Rightarrow 0.6004Q^2 - 0.632Q = 0$

Use Quadratic EQUATION, to FIND THE VALUE OF Q:

$-b \pm \sqrt{b^2 - 4(a)(c)}\ /\ 2a$, WHERE $a = 0.6004$, $b = 0.632$

$Q_{max_1} = 0.358\,V$ $\quad Q_{max_2} = -1.6572$

$\therefore$ ~~At Qmax~~ At 95%, $Q^*_{max} = \frac{1 - .95Q_{max}}{Q_{max}} = \frac{1 - .95(0.358)}{0.358} = 1.84\,V$

AND $t = RC\ln(1.84)/1.84 = 0.044_s \ln(1.84)/1.84 = 0.01458\,s$

CONTINUATION PAGE 6 OF 8

4) (10 pts.) If the charge in problem 3 has a mass of 3.0x10^{-7} kg, what is the radius of curvature for the particle's motion?

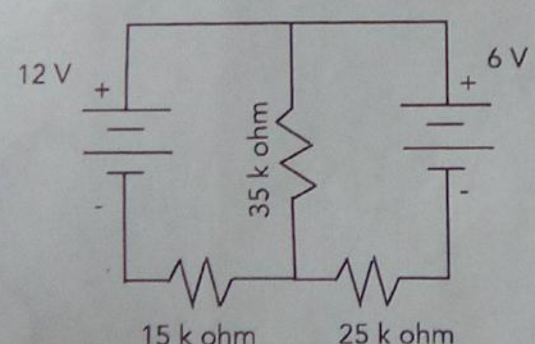
SUPPOSE $\vec{F_B} = quB = \frac{mv^2}{r}$, USING THE SAME NOTATIONS IN PROBLEM 3 WITH $\vec{F_B} = q\vec{v}\vec{B}$, m = MASS and r = radius.
LET $r = \frac{mv^2}{q\vec{v}\vec{B}} = \frac{mv}{qB}$. SO, $r = (3.0 \times 10^{-7} kg)(5.5 \times 10^{5} m/s) / (49.00 \times 10^{-6} C)(2T) = 0.016\ m$ OR $1.67 \times 10^{-2}\ m$.

$\therefore r = 1.67 \times 10^{-2}\ m$, WHICH IS THE RADIUS OF CURVATURE OF THE PARTICLE'S MOTION IN CIRCULAR PATH.

5) (10 pts.) Magnetic torque is:

$$\tau = BIAsin\theta$$

A loop of wire has a radius of 3cm and is 30 degrees to a 2 T field with 1.5 A current. What is the torque (state units)? 4.24×10^{-3} N·m



SUPPOSE $\vec{F_2} = \vec{F_4} = I_a \vec{B}$, WHERE F_2 AND F_4 ARE MAGNETIC FORCES OF MAGNETIC TORQUE, I_a = CURRENT OF THE BEGINNING OF THE WIRE, AND $\vec{B}$ = MAGNETIC FIELD OF THE MAGNETIC TORQUE. LET $\tau_{max} = IAB$, WHERE τ_{max} = MAXIMUM TORQUE. LET $\tau = IAB\sin\theta$, WHERE $0° \leq \theta \leq 90°$.
LET A = AREA OF A LOOP = AREA OF A CIRCLE = πr^2.
SO, $A = \pi r^2 = \pi(3/100)^2 = 2.83 \times 10^{-3}\ m^2$.
SO, $\tau = BIA \sin\theta = (2T)(1.5A)(2.83 \times 10^{-3}\ m^2) \sin 30.0 = 4.24 \times 10^{-3}\ N \cdot m$

$\therefore \tau = 4.24 \times 10^{-3}\ N \cdot m$, WHICH IS THE MAGNETIC TORQUE

#2 (b) HOW LONG WOULD IT TAKE IF A SECOND 8.0 uF CAPACITOR IS ADDED IN SERIES?

SUPPOSE ~~[illegible]~~ = $RC = \tau$. LET $C_{equivalence} = \left[\frac{1}{C_1} + \frac{1}{C_2}\right]^{-1}$ WHERE $C_1 = 8.0\,uF$, AND $C_2 = 8.0\,uF$. LET $\tau = RC_{eq} = (5.5 \times 10^{3}\,\Omega)(4.0 \times 10^{-6}) = 0.022\,s$.

SO, ~~[illegible]~~ $q = (0.022) = \left(\frac{1 - 0.95 Q_{max}}{Q_{max}}\right)\left(1 - e^{-t/RC}\right)$, WHERE $RC = 0.022\,s$. Using THE RESULT FROM QUADRATIC EQUATION ON (a) TO FIND Q_{max} AT 95% CHARGED OF $C_{equivalence}$.

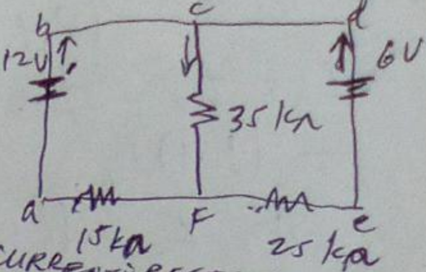
$\therefore$ AT 95%, $Q_{max} = 1.84\,V$ AND $t = RC \ln((84)/1.84) = 0.00729\,s$.

$\therefore$ AT 95%, $t = 0.00729\,s$, WHICH WILL IT TAKE FOR THE FULLY DISCHARGED CAPACITORS EQUIVALENCE TO BE CHARGED.

~~[illegible]~~

#5 IN A LOOP OF WIRE

6) (20 pts.) Find the current through each of the three resistors.



SUPPOSE $I_1 + I_2 - I_3 = 0$, WHERE I_1 = CURRENT IN RESISTOR 1, I_2 = CURRENT IN RESISTOR 2, AND I_3 = CURRENT IN RESISTOR 3. ~~Apply~~ APPLYING KIRCHHOFF'S JUNCTION RULE, LET $I_2 = I_1 + I_3$, AND START AT POINT C. IN GENERAL, KIRCHHOFF'S JUNCTION IS GOING CLOCKWISE AROUND LOOP ABCFA TO OBTAIN: ~~12V~~ $12V - 35k\Omega I_2 - 15k\Omega I_1 = 0$.

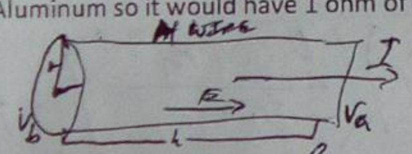
LET $I_1 = (12V/15k\Omega) - \left(\frac{35k\Omega}{15k\Omega}\right)I_2 = \left(\frac{12V}{15000\Omega}\right) - \left(\frac{35000\Omega}{15000\Omega}\right)I_2$.

SO, ~~8.00×10~~ $I_1 = (8.00 \times 10^{-4} A) - (2.3)I_2$

~~Apply~~ KIRCHHOFF'S LOOP RULE TO GO COUNTERCLOCKWISE ~~AROUND~~ LOOP EDCFE TO OBTAIN: $6V - 35k\Omega I_2 - 25k\Omega I_3 = 0$. LET $I_3 = (6V/25k\Omega) - (35k\Omega/25k\Omega)I_2 = (6V/25000\Omega) - \left(\frac{35000\Omega}{25000\Omega}\right)I_2$.

CONTINUATION PAGE 8 OF 8

7) (10 pts.) Aluminum has a resistivity of 2.8×10^{-8} ohm-meter. How would you shape 0.001 m^3 of Aluminum so it would have 1 ohm of resistance? (more than one correct answer)



SUPPOSE $R = \rho \frac{l}{A}$, WHERE R = RESISTANCE, ρ = RESISTIVITY OF A ALUMINUM WIRE, l = LENGTH OF ALUMINUM WIRE, AND A = SURFACE OF CROSS-SECTIONAL AREA OF ALUMINUM WIRE. LET THE VOLUME OF AL WIRE = $\pi r^2 h$, WHERE r = RADIUS AND h = HEIGHT. LET $r = \sqrt{\frac{0.001m^3}{\pi h}}$ AND $h = 0.001m^3/\pi r^2$. LET THE ~~VOLUME~~ AREA OF AL WIRE =

$$2\pi r^2 + 2\pi r h = 2\pi\left(\frac{0.001m^3}{\pi h}\right) + 2\pi\left(\sqrt{\frac{0.001m^3}{\pi h}}\right)\left(\frac{0.001m^3}{\pi r^2}\right).$$

LET $J = \sigma E$, WHERE J = CURRENT DENSITY OF AL WIRE, σ = CONDUCTIVITY OF AL WIRE, AND E = ELECTRIC FIELD. LET $\Delta V = V_b - V_a = El$, WHERE ΔV = POTENTIAL DIFFERENCE BETWEEN V_b AND V_a. LET $\Delta V = El = \frac{lJ}{\sigma} = \left(\frac{l}{\sigma A}\right)I = RI$, WHERE I = CURRENT. SO, $\Delta V = RI \Rightarrow R = \Delta V/I$, ~~WHERE~~ ∴ $1\Omega = 1V/1A$.

CONTINUATION PAGE 8 OF 8

#6 So, $I_3 = (2.4\times10^{-4}A) - (1.4)I_2$.

Let $I_2 = I_1 + I_3 = (8.00\times10^{-4}A) - (2.3)I_2 + (2.4\times10^{-4}A) - (1.4)I_2$.

So, $I_2 = (1.04\times10^{-3}A) - (3.7)I_2 \Rightarrow 4.7I_2 = 1.04\times10^{-3}A$

$\Rightarrow I_2 = (1.04\times10^{-3}A)/4.7 = 2.21\times10^{-4}A$

$\therefore I_{R_1} + I_{R_2} - I_{R_3} \cong 0$, WHERE I_{R_1} = CURRENT OF RESISTOR 1, I_{R_2} = CURRENT OF RESISTOR 2, AND I_{R_3} = CURRENT OF RESISTOR 3.

$\therefore IR_1 = (8.00\times10^{-4}A) - (2.3)(2.21\times10^{-4}A) = 2.92\times10^{-4}A$

$IR_2 = 2.21\times10^{-4}A$

$IR_3 = (2.4\times10^{-4}A) - (1.4)(2.21\times10^{-4}A) = -6.94\times10^{-5}A$

#7 $\therefore R = \rho\frac{l}{A} = (2.8\times10^{-8}\,\Omega\cdot m)\left(\frac{0.001m^3}{\pi r^2}\right) / \left[2\pi\left(\frac{0.001m^3}{\pi h}\right) + 2\pi\left(\sqrt{\frac{0.001m^3}{\pi h}}\right)\left(\frac{0.001m^3}{\pi r^2}\right)\right.$

$$\therefore R = (2.8\times10^{-8}\,\Omega\cdot m)\left[\frac{\left(\frac{0.001m^3}{\pi r^2}\right)}{2\pi\left(\frac{0.001m^3}{\pi h}\right) + 2\pi\left(\sqrt{\frac{0.001m^3}{\pi h}}\right)\left(\frac{0.001m^3}{\pi r^2}\right)}\right]$$

Physics 236 **Test Three**

Name: JERICO MATIAS CRUZ

Due Date
November 24, 2021

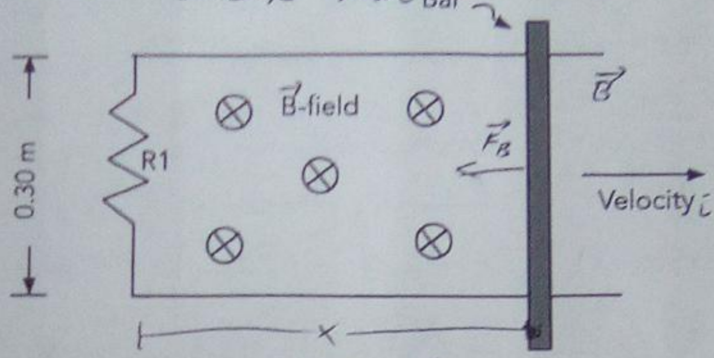


DIAGRAM 1.

Figure 1

1) (30 pts.) A 3.00 T magnetic field is going into the page while a metal bar of mass 0.03 kg is being pulled at 9.00 m/s in the direction shown. Resistor R1 is 10 ohms, what direction and magnitude of the current flowing through the resistor?

At time = 0 s, the bar is no longing being pulled and is sliding without friction at 9 m/s. Find an equation for velocity versus time then find the velocity after 1 second of sliding.

(a) WHAT DIRECTION AND MAGNITUDE OF THE CURRENT FLOWING THROUGH THE RESISTOR?

SUPPOSE $I = \frac{|\mathcal{E}|}{R}$, WHERE I = MAGNITUDE OF THE INDUCED CURRENT FLOWING THROUGH THE RESISTOR, R = RESISTOR OR RESISTANCE OF THE CIRCUIT, AND $|\mathcal{E}|$ = THE ABSOLUTE VALUE OF THE INDUCED MOTIONAL EMF. USING FARADAY'S LAW OF INDUCTION, LET $\mathcal{E} = -\frac{d\Phi_B}{dt}$, WHERE $\Phi_B = \int \vec{B} \cdot d\vec{A}$ IS THE MAGNETIC FLUX THROUGH THE LOOP. LET $\Phi_B = B\ell x$, AS THE AREA OF THE CIRCUIT CHANGES WITH THE MOVEMENT OF THE BAR; WHERE B = MAGNITUDE OF THE MAGNETIC FIELD, ℓ = LENGTH OF TWO WIRES IN BETWEEN THE RESISTOR OR TWO RAILS OF THE BAR ON DIAGRAM 1, AND x = POSITION OF THE BAR.

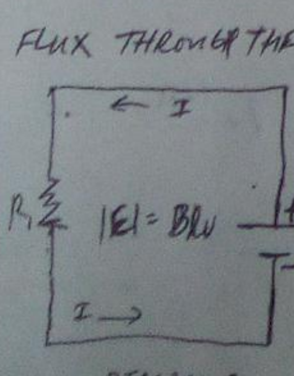


DIAGRAM 2

LET $\mathcal{E} = -\frac{d\Phi_B}{dt} = -\frac{d}{dt}(B\ell x) = -B\ell\frac{dx}{dt} = -B\ell v$, WHERE $B = 3.00\,T$, $\ell = 0.30\,m$, AND $v = 9.00\,m/s$. SO, $|\mathcal{E}| = |-B\ell v| = |[-(3.00T)(0.30m)(9.00\,m/s)]| = 8.10\,V$. THEREFORE, $I = \frac{|\mathcal{E}|}{R} = \frac{|8.10\,V|}{10.0\,\Omega} = 8.10 \times 10^{-2}\,A$. THEREFORE, THE MAGNITUDE OF INDUCED CURRENT FLOWING THROUGH THE RESISTOR IS $8.10 \times 10^{-2}\,A$; AND THE DIRECTION OF THE INDUCED CURRENT THROUGH THE RESISTOR IS COUNTERCLOCKWISE

SEE CONTINUATION ON PAGE 2 OF 8

SEE DIAGRAM 2 ABOUT THE COUNTERCLOCKWISE DIRECTION OF THE INDUCED CURRENT FLOWING THROUGH THE RESISTOR.

(b) FIND AN EQUATION FOR VELOCITY VERSUS TIME.

SUPPOSE $F_B = -I\ell B$, WHERE (−) SIGN SHOWS THAT THE MAGNETIC FORCE IS MOVING IN THE OPPOSITE DIRECTION OF THE INITIAL VELOCITY, I = CURRENT, ℓ = DISTANCE BETWEEN TWO PARALLEL RAILS OF THE BAR, AND B = MAGNITUDE OF THE MAGNETIC FIELD. USING THE NEWTON'S SECOND LAW OF MOTION, LET $F_B = F_x = ma = -I\ell B = m\frac{dv}{dt} = -\left(\frac{B\ell v}{R}\right)\ell B = -\frac{B^2\ell^2}{R}v$, WHERE m = MASS, a = ACCELERATION, AND $I = \frac{B\ell v}{R}$ FROM QUESTION (a). Let $\frac{dv}{v} = -\left(\frac{B^2\ell^2}{mR}\right)dt$, WHERE v = VELOCITY. At $t=0$ AND $v = v_i$, LET $\int_{v_i}^{v_f}\frac{dv}{v} = -\frac{B^2\ell^2}{mR}\int_0^t dt$, WHERE $\frac{B^2\ell^2}{mR}$ REMAINS CONSTANT. Let $\tau = mR/B^2\ell^2$, WHERE τ IS THE INVERSE OF $\frac{B^2\ell^2}{mR}$. Let $\ln\left(\frac{v}{v_i}\right) = -\ln^{-t/\tau} \Rightarrow \frac{v_f}{v_i} = e^{-t/\tau}$. THEREFORE, $v_f = v_i e^{-t/\tau}$, WHERE v_f = FINAL VELOCITY, v_i = INITIAL VELOCITY, AND $e^{-t/\tau}$ = EXPRESSION OF NEGATIVE TIME DIVIDED BY TAU, WHICH IS EQUAL TO $mR/B^2\ell^2$.

~~THEREFORE,~~

(c) FIND THE VELOCITY AFTER ~~AFTER~~ 1 SECOND OF SLIDING.

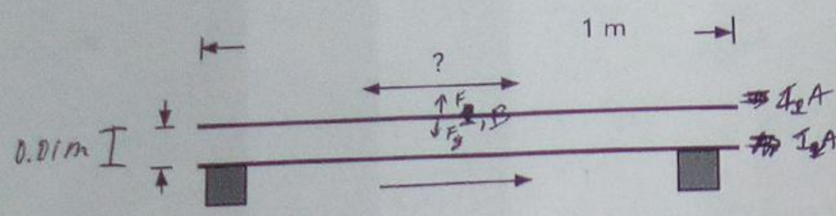
SUPPOSE $v_f = v_i e^{-t/\tau}$, USING THE DEFINITION FROM QUESTION (b). LET $\tau = \frac{mR}{B^2\ell^2}$, WHERE $m = 0.03\,kg$, $R = 10\,\Omega$, $B = 3.00\,T$, AND $\ell = 0.30\,m$.

$$\text{SO, } \tau = \frac{(0.03\,kg)(10\,\Omega)}{[(3.00T)^2(0.30m)^2]} = 3.70\times10^{-1}\ kg\cdot ohm/T^2\cdot m^2$$

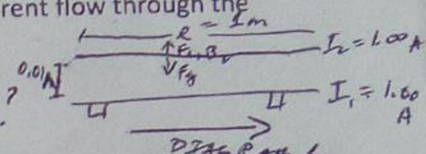
SO, $v_f = v_i e^{-t/\tau}$, WHERE $v_i = 9.00\,m/s$, $t = 1\,s$, AND $\tau = 3.70\times10^{-1}\,\frac{kg\cdot ohm}{T^2\cdot m^2}$

$$\text{THEREFORE, } v_f = (9.00\,m/s)\left(e^{(-1/3.70\times10^{-1}\,kg\cdot ohm/T^2\cdot m^2)}\right) = 6.03\times10^{-1}\,m/s.$$

$\therefore$ $6.03\times10^{-1}\,m/s$ IS THE FINAL VELOCITY AFTER 1 SECOND OF SLIDING.



2) (20 pts.) Two one-meter rods are separated by 0.01 m with the bottom rod resting on a table and the top rod levitated by forces due to current in the rod below. Both rods have 1.00 amp of current. What is the mass of the top rod and what is the direction of current flow through the top rod?



(a) WHAT IS THE MASS OF THE TOP ROD?

Suppose $\sum \vec{F} = \vec{F}_1 + \vec{F}_g = 0$ WHERE $\sum \vec{F}$ = SUM OF ALL FORCES OR TOTAL FORCE, F_1 = MAGNETIC FORCE EXERTED FROM ROD RESTING ON A TABLE, AND F_g = GRAVITATIONAL FORCE EXERTED FROM THE TOP ROD LEVITATED BY MAGNETIC FORCE DUE TO CURRENT ON THE ROD RESTING ON A TABLE. LET $F_1 = I_1 l B_2$, WHERE $I_1 = 1.00\ A$, $l = 1.00\ m$, $B_2 = \left(\frac{\mu_0 I_2}{2\pi a}\right)$. Let $B_2 = \frac{\mu_0 I_2}{2\pi a}$, WHERE $\mu_0 = 4\pi \times 10^{-7}$ T·m/A, $I_2 = 1.00\ A$, AND $a = 0.01\ m$. LET $F_1 = I_1 l B_2 \cos\theta \hat{k} = \frac{I_1 l I_2 \mu_0}{2\pi a}\cos\theta \hat{k}$. LET $F_g = -mg\hat{k}$, WHERE m = MASS OF THE TOP ROD LEVITATED BY F_1, AND $g = 9.8\ m/s^2$. Let $\sum \vec{F} = \vec{F}_1 + \vec{F}_g = 0 \Rightarrow \frac{\mu_0 I_1 I_2}{2\pi a} l \cos\theta \hat{k} - mg\hat{k} = 0$.

SO, $mg\hat{k} = \frac{\mu_0 I_1 I_2}{2\pi a} l \cos\theta \hat{k} \Rightarrow 2\pi a\, mg\hat{k} = \mu_0 I_1 I_2 l \cos\theta \hat{k} \Rightarrow$

$$m = \frac{\mu_0 I_1 I_2 l \cos\theta \hat{k}}{2\pi a g \hat{k}}$$, WHERE $\theta = 0^\circ = 1$ OR $\theta = 90^\circ = 0$.

$\therefore$ MASS OF THE TOP ROD $= \frac{[(4\pi \times 10^{-7}\ T\cdot m/A)(1.00\ A)(1.00\ A)(1.00\ m)\cos(0^\circ)\hat{k}]}{[2\pi(0.01\ m)(9.80\ m/s^2)]} =$

$= 2.04 \times 10^{-6}\ kg$

(b) WHAT IS THE DIRECTION OF CURRENT FLOW THROUGH THE TOP ROD?

Suppose $F_g = F_1$, USING THE EQUATION ON QUESTION 2(a).

SEE CONTINUATION ON PAGE 4 OF 8

LET $F_g = +mg\hat{k}$, WHERE m = MASS OF THE TOP ROD = 2.04×10^{-6} kg, AND $g = 9.80\ m/s^2$. LET $F_1 = \frac{\mu_0 I_1 I_2 l}{2\pi a} \cos\theta \hat{k}$, WHERE $I_1 = I_2 = 1.00$ A, $l = 1.00$ m, $\theta = 0° = 1$, AND $a = 0.01$ m. Let $-mg\hat{k} = \frac{\mu_0 I_1 I_2 l}{2\pi a} \cos\theta \hat{k} \Rightarrow$ $\mu_0 = \frac{+mg\hat{k}\, 2\pi a}{I_1 I_2 l \cos\theta \hat{k}}$. SO, $\mu_0 = \frac{+[(2.04 \times 10^{-6} kg)(9.80\ m/s^2)(2\pi)(0.01 m)]}{[(1.00 A)(1.00 A)(1.00 m)\cos(0°)]} =$ $= +1.26 \times 10^{-6}$ T-m/A. THEREFORE, μ_0 IS A CONSTANT, ALSO KNOWN AS THE PERMEABILITY OF FREE SPACE, WHICH IS EQUIVALENT TO $4\pi \times 10^{-7}$ T·m/A.

∴ USING CURRENT BALANCE, $mg\hat{k} = \frac{\mu_0 I_1 I_2 l}{2\pi a} \cos\theta \hat{k}$, THE TOP ROD'S CURRENT IS RUNNING/FLOWING IN OPPOSITE DIRECTION. EVEN THOUGH THESE TWO STRAIGHT, PARALLEL RODS, ~~WHICH~~ ARE CARRYING THE SAME MAGNITUDE OF CURRENT. IN ADDITION, USING CURRENT BALANCE, IT WILL ALLOW YOU TO MEASURE THE FORCE OF REPULSION BETWEEN TWO STRAIGHT, PARALLEL RODS, CARRYING THE SAME MAGNITUDE OF CURRENT, SEE DIAGRAM 2.

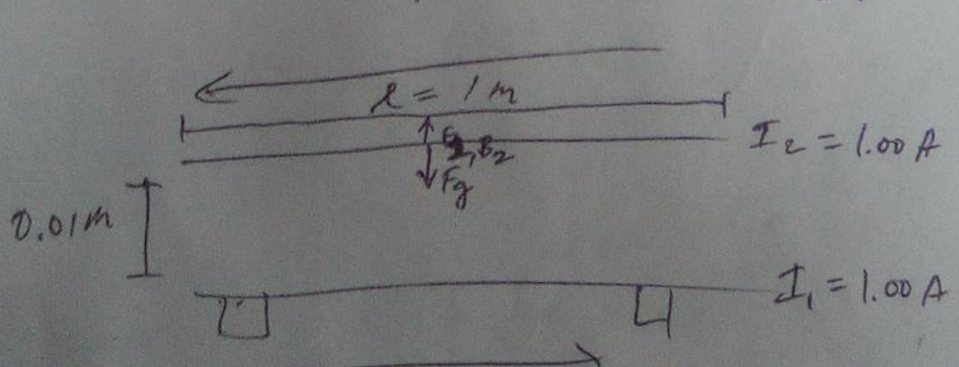


DIAGRAM 2

3) (30 pts.) Magnetic tape is running at 2 m/s past closed loops of total area 0.001 m^2.
The magnetic field on the tape changes:
$B = 0.03Tx^2$, where x is distance in meters.
Find the EMF in the loop as a function of time.
Assume the loops are thin, so flux is uniform for the whole area and B = 0 at t = 0, what is the voltage after 0.5 s?

(a) FIND THE EMF IN THE LOOP AS A FUNCTION OF TIME.

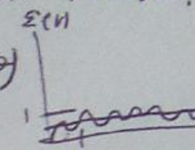


FIGURE 1

SUPPOSE $\mathcal{E} = -\frac{d}{dt}(BA\cos\theta)$, WHERE $(BA\cos\theta)$ IS EQUIVALENT OF THE MAGNETIC FLUX THROUGH A LOOP ENCLOSING AN AREA (A) AND SPECIFYING IN A UNIFORM MAGNETIC FIELD (B) WITH ANGLE (θ) BETWEEN THE MAGNETIC FIELD AND THE NORMAL LOOP. LET $\mathcal{E} = -\frac{d\Phi_B}{dt} = -\frac{d(BA\cos\theta)}{dt}$,

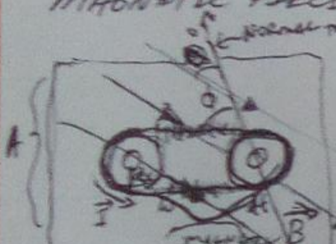


DIAGRAM 1
MAGNETIC TAPE RECORDING

WHERE $\vec{B}$, A, ANGLE θ BETWEEN $\vec{B}$ AND THE NORMAL LOOP CHANGE WITH TIME UNDER FARADAY'S LAW OF INDUCTION. SEE DIAGRAM 1 OF THE MAGNETIC TAPE RECORDING. LET $B = 0.03Tx^2$, WHERE X = DISTANCE IN METERS. LET $\frac{dx^2}{dt} = 2X = 2V$. LET B = $B = 0.03T(2V)$, BY SUBSTITUTING $\frac{dx^2}{dt} = 2X = 2V$.

~~LET $\mathcal{E}_{MAX} = \omega AB$, WHERE ω = ANGULAR SPEED OF THE MAGNETIC TAPE.~~ LET $\Phi_B = BA\cos\omega t$, WHERE Φ_B IS IN WEBERS, ω = ANGULAR SPEED OF THE MAGNETIC TAPE, AND t = TIME. LET $\omega t = \theta$. SO $\mathcal{E} = -\frac{d\Phi}{dt} = -\frac{d}{dt}(BA\cos(\omega t)) = +\omega BA\sin\omega t$ volts,

WHERE $\omega = 2$ m/s. $\therefore$ $\mathcal{E}(t) = \omega BA\sin(\omega t)$ Volts $= (2\text{ m/s})(0.03T(2(2\text{ m/s}))(0.001m^2)\sin[(2\text{ m/s})(t)]$ volts $= (2.4\times10^{-4})\sin(2t)$ volts.

$\therefore$ $\mathcal{E}(t) = 2.4\times10^{-4}\sin(2.00t)$ Volts. SEE ~~DIAGRAM~~ FIGURE 1 AS $0 \le t \ge 0$.

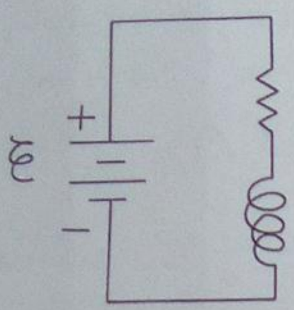
(b) WHAT IS THE VOLTAGE AFTER 0.5 s?

SUPPOSE $\mathcal{E}(t) = 2.4\times10^{-4}\sin(2.00t)$ Volts, WHERE t IS

SEE CONTINUATION ON PAGE 6 OF 8

IN SECOND. LET $t = 0.5s$, ASSUMING THE LOOPS ARE THIN, AND SO THE FLUX IS UNIFORM FOR THE WHOLE AREA AND $B = 0$ AT $t = 0$. SO, $\mathcal{E}(t) = 2.4 \times 10^{-4} \sin(2.00t)$ volts $\Rightarrow$ at $t = 0_s$, $\mathcal{E}(0) = 2.4 \times 10^{-4} \sin(2.00(0)) \doteq 0$ VOLT $= 0V$. SO, at $t = 0.5s$, $\mathcal{E}(0.5) = 2.4 \times 10^{-4} \sin(2.00(0.5))$ volts.

$\therefore \mathcal{E}(0.5) = 2.4 \times 10^{-4} \sin(2.00(0.5))$ volts $= 2.4 \times 10^{-4} \sin(1)$ volts $= (2.40 \times 10^{-4})(1.74 \times 10^{-2})$ volts $= 4.18 \times 10^{-6}$ V.



4) (20 pts.) Find the current as a function of time for an RL circuit starting with, $\varepsilon = -L\frac{dI}{dt}$, $\varepsilon = IR$ and Kirchhoff's rules. Assume that I = 0 at t = 0 and explain each step. Find the power dissipated by the resistor then find total energy dissipated after time t.

(a) FIND THE CURRENT AS A FUNCTION OF TIME FOR AN RL CIRCUIT STARTING WITH, $\mathcal{E} = -L\frac{dI}{dt}$; $\mathcal{E} = IR$ AND KIRCHHOFF'S RULES.

SUPPOSE $I = \frac{\mathcal{E}}{R}$, WHERE I = CURRENT, R = RESISTANCE, AND $\mathcal{E}$ = EMF OR ELECTROMOTIVE FORCE. LET $x = (\mathcal{E}/R) - I$, WHERE $dx = -dI$. LET $\mathcal{E} = -L\frac{dI}{dt}$. USING KIRCHHOFF'S LOOP EQUATION, LET $x + \frac{L\,dx}{R\,dt} = 0$. SO, $\frac{dx}{x} = -\frac{R}{L}dt$.

$\ln\frac{x_f}{x_i} = -\frac{R}{L}t$

SO, $\int_{x_i}^{x_f}\frac{dx}{x} = -\frac{R}{L}\int_{t_i}^{t_f} dt \Rightarrow I(t) = \frac{\mathcal{E}}{R}\left(1 - e^{-Rt/L}\right)$.

$\therefore I(t) = \frac{\mathcal{E}}{R}\left(1 - e^{-Rt/L}\right)$

$\therefore$ At $t = 0$, $I(0) = \frac{\mathcal{E}}{R}\left(1 - e^{-R(0)/L}\right) = \frac{\mathcal{E}}{R}\left(1 - e^{(0)}\right) =$

~~(b) FIND THE POWER DISSIPATED BY THE RESISTOR.~~

$= \frac{\mathcal{E}}{R}(1-1) = \frac{\mathcal{E}}{R}(0) = 0.$

$\therefore$ At $t = 0$, $I = 0$.

SEE CONTINUATION ON PAGE 8 OF 8.

(b) FIND THE POWER DISSIPATED BY THE RESISTOR.

SUPPOSE $P = I\Delta V_R$, WHERE P = POWER, I = CURRENT, ΔV_R = POTENTIAL DIFFERENCE OF RESISTOR. LET $P = I\Delta V_R = I(IR)$, WHERE $\Delta V_R = IR$. SO, $I\Delta V_R = I(IR) = I^2R$.

$\therefore P_R = I\Delta V_R = I(IR) = I^2R$, WHERE P_R = POWER OF RESISTOR DISSIPATED IN WATTS.

(c) FIND THE TOTAL ENERGY DISSIPATED AFTER TIME t.

SUPPOSE $\mathcal{E} - \Delta V_R - \Delta V_L = 0$, OR $\mathcal{E} - iR - L\frac{di}{dt} = 0$ (i = CURRENT) WHERE $\mathcal{E}$ = EMF = ELECTROMOTIVE FORCE, ΔV_R = POTENTIAL DIFFERENCE OF RESISTOR, AND ΔV_L = POTENTIAL DIFFERENCE OF INDUCTOR, AND USING KIRCHHOFF'S LOOP RULES. Let $iR + L\frac{di}{dt} = 0$, WHERE $iR = \Delta V_R$, $L\frac{di}{dt} = \Delta V_L$, AND $\mathcal{E} = 0$. LET $P_R = I\Delta V_R = I(IR) = I^2R$. USING THE POWER OR ENERGY DISSIPATED BY THE RESISTOR. LET $U = \frac{1}{2}LI^2 \Rightarrow$

$\frac{dU}{dt} = LI\frac{dI}{dt}$. IN SERIES, LET $I = \frac{\mathcal{E}}{R}(1 - e^{-t/\tau})$, WHERE $\tau = \frac{L}{R}$. LET $\frac{dI}{dt} = \frac{\mathcal{E}}{L}e^{-t/\tau}$. LET $e^{-t/\tau} = 1 - \frac{IR}{\mathcal{E}}$.

SUBSTITUTING $\frac{dI}{dt} = \frac{\mathcal{E}}{L}e^{-t/\tau} = \frac{\mathcal{E}}{L}\left(1 - \frac{IR}{\mathcal{E}}\right) = I(\mathcal{E} - IR)$.

SUBSTITUTING $\frac{dU}{dt} = LI\frac{dI}{dt} = I(\mathcal{E} - IR)$. USING THE POWER OR ENERGY DISSIPATED BY THE INDUCTOR. SO, $i = \frac{\mathcal{E}}{R}e^{-t/\tau} = I_i e^{-t/\tau}$, WHERE $I_{initial}$ = INITIAL CURRENT = $\mathcal{E}/R$, AND i = CURRENT.

$\therefore i(t) = I_{initial}\, e^{-t/\tau}$

$\therefore$ At $t = 0$ AND $I_{initial} = 0$, $i(0) = (0)e^{-(0)/\tau} = (0)(1) = 0$. DUE TO LAW OF CONSERVATION OR ENERGY CONSERVATION, THE TOTAL POWER FROM $\mathcal{E}$ TO R AND L DISSIPATES BUT STORED AT $\frac{di}{dt} = 0$.

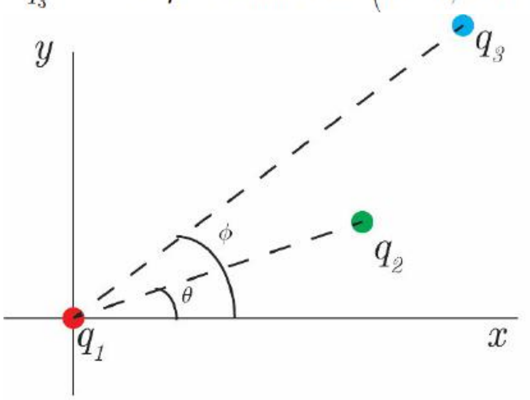
Name: Jerico Matias Cruz **September 29, 2021**
PHYS 236 –Fall 2021 Prof. Schmitz

The purpose of this exercise is to review the rules of vector addition and explore the force between point charges.

1) Download this Word Document to your computer. Rename this file to
You will edit this document. Feel free to add lines and adjust the spacing as needed. Add your name to the top of this page. **(DONE)**

2) Consider a system of three, point charges as follows

$$q_1 = +1.5\ \mu\text{C located at } (0\text{ cm}, 0\text{ cm})$$
$$q_2 = +0.2\ \mu\text{C located at } (3\text{ cm}, 1\text{ cm})$$
$$q_3 = -0.2\ \mu\text{C located at } (4\text{ cm}, 3\text{ cm})$$



On a separate sheet of paper, find the *x* and *y* components of the net force on charge q_1. You should sketch the system and indicate the direction of the force from q_2 on q_1 and the force from q_3 on q_1. (**DONE)**

<u>Mathematical Proofing of Newton's Second Law & Newton's Third Law: Net Force & Electrostatic Force</u>

(1)Newton's Second Law
Suppose Newton's Second Law = Force = mass x acceleration = m x a = m x (dv/dt), given v = velocity, t = time. If (dv/dt) = 0, then F = m x 0 = 0, when derivative of velocity is zero. Let $F_1 = m_1$ x $a_1 = m_1$ x (dv_1/dt_1); $F_2 = m_2$ x $a_2 = m_2$ x (dv_2/dt_2).

So, $\Sigma F_{net} = F_1 + F_2 = [m_1$ x $(dv_1/dt_1)] + [m_2$ x (dv2 /dt2)].

Therefore, $\Sigma F_{net} = F_1 + F_2$.

(2) Finding Net Force Using Newton's Second Law

Suppose $\Sigma F_{net1} = F_2 + F_3$. Given $q_1 = +1.5$ micro C located at (0 cm, 0 cm); $q_2 = +0.2$ micro C located at (3 cm, 1 cm); and $q_3 = -0.2$ micro C located at (4 cm, 3 cm). Let $\Sigma F_{net1} = (q_3 - q_1) + (q_2 - q_1)$.

So, $F_2 = (q_3 - q_1)$; $F_3 = (q_2 - q_1)$.

Therefore, $\Sigma F_{net1} = F_2 + F_3$.

(3) Finding Net Force/Electrostatic Force Using Newton's Third Law

(a) Suppose $F_1 = -F_2$. Let $F_1 = F_{21} = F_{31}$ = k x $[(q_1$ x $q_2) / r^2]$, where F is electrostatic force, k = Coulomb's constant or electrostatic constant, q_1, q_2 = charges, and r distance of separation between charges 1 and 2. Given

q_1 = +1.5 micro C located at (0 cm, 0 cm); q_2 = +0.2 micro C located at (3 cm, 1 cm); and q_3 = -0.2 micro C located at (4 cm, 3 cm).

Let $F_1 = F_{21} = F_{31} = = k \times [(q_2 \times q_3) / r^2]$, given F is electrostatic force, k = Coulomb's constant or electrostatic constant, which is to 9×10^9 $N.m^2.C^{-2}$, q_2, q_3 = charges, and r = distance of separation between charges 2 and 3.

So, $F_1 = k \times [(q_2 \times q_3) / r^2]$, given r is the slope of (q_2, q_3) = $[(q_{32y} - q_{21y}) / (q_{32x} - q_{21x})]$, or tan ϕ, or tan θ.

Therefore, $F_1 = k \times [(q_2 \times q_3) / r^2]$, as slope of r = [(3cm – 1cm) / (4cm – 3cm)] = 2; $\phi = 45°$; $\theta = 45°$.

For r_{31}:

Let tanϕ = o / a, using trigonometric equation. Given that $\phi = 45°$; q_1 = +1.5 micro C located at (0 cm, 0 cm); q_2 = +0.2 micro C located at (3 cm, 1 cm); and q_3 = -0.2 micro C located at (4 cm, 3 cm); and o = opposite of a triangle and a = is adjacent of a triangle.

In this case, q_3 is a right triangle or Pythagorean triangle in which it has the properties of the following: $\phi = 45°$, o = 4 cm, and a = 3 cm.

Let a = q_3x = a, b = q_1x =o, and c =r_{31} =h, where h is the hypothenuse of a triangle, q_3x = distance of the adjacent of the Pythagorean triangle, q_1x = distance of the opposite of the Pythagorean triangle, and r_{31} = the distance of the hypothenuse of the Pythagorean triangle.

So, $a^2 + b^2 = c^2 ==> c2 = a^2 + b^2$.

Therefore, $r_{31} = q_3x^2 + q_1x^2 = \sqrt{3^2 + 4^2} = 5$ cm

For r_{21}:

Let tan θ = o / a, using trigonometric equation. Given that $\theta = 45°$; q_1 = +1.5 micro C located at (0 cm, 0 cm); q_2 = +0.2 micro C located at (3 cm, 1 cm); and q_2 = +0.2 micro C located at (3 cm, 1 cm) ; and o = opposite of a triangle and a = is adjacent of a triangle.

So, tan θ = o / a ==> a = o / tan θ, where o = 3 cm and $\theta = 45°$.

Therefore, a = 3 / tan (45) = 3 cm.

(b) Suppose $V_{q3} - V_{q2} = - \int_{q2}^{q3} E \times ds = E \times ds = - k (q/r^2)\, dr$, where V_{q2} is the voltage or charge of point q_2, V_{q3} is the voltage or charge of point q_3, E is the electric field, k Coulomb's constant or electrostatic constant, which is to 9×10^9 $N.m^2.C^{-2}$, ds = derivative of a sphere, r = distance of separation between charges 2 and 3. Given q_1 = +1.5 micro C located at (0 cm, 0 cm); q_2 = +0.2 micro C located at (3 cm, 1 cm); and q_3 = -0.2 micro C located at (4 cm, 3 cm).

Another way to calculate r_{21} and r_{31} if and only if voltages for q_2 and q_3 are present.

Let $V_{q3r31} - V_{q2r21} = - k \times q - \int_{q2r21}^{q3r31} (dr/r^2) = k\, q/r \,\Big|_{q2r21}^{q3r31} = k \times q\, [\, (1/q_3r_{31}) - (1/q_2r_{21})]$. Given than $V_{q2r21} = 0$ at $q_2r_{21} = \infty$.

So, $V_{q3r31} = k \times (q_3 / r_{31}) ==> r = (k \times q_3) / V_{q3r31.}$

Therefore, $r_{31} = (k \times q_3) / V_{r31.}$

So, $V_{q2r21} = k \times (q_{21} / r_{21})$ ==> $r = (k \times q_2) / V_{q2r21}$, where $V_{q3r31} = 0$ at $q_2r_{21} = -\infty$.

Therefore, $r_{21} = (k \times q_2) / V_{r21.}$

(c) Suppose $F_1 = - F_{2\,.}$ Let $F_1 = F_{21} = F_{31} = k \times [(q_1 \times q_2) / r^2]$, where F is electrostatic force, k = Coulomb's constant or electrostatic constant, q_1, q_2 = charges, and r distance of separation between charges 1 and 2. Given q_1 = +1.5 micro C located at (0 cm, 0 cm); q_2 = +0.2 micro C located at (3 cm, 1 cm); and q_3 = -0.2 micro C located at (4 cm, 3 cm).

For $F_{21:}$

Let $F_1 = F_{21} = F_{31} = k \times [(q_2 \times q_3) / r^2]$, given F is electrostatic force, k = Coulomb's constant or electrostatic constant, which is to 9×10^9 N.m^2.C^{-2}, $q_{2\,,}$ q_1 = charges, and r = distance of separation between charges 2 and 1.

So, $F_{net2} = F_{21} = k \times [(q_2 \times q_1) / r^2_{21}]$, where k = 9×10^9 N.m^2.C^{-2}; q_2 = +0.2 micro C; q_1 = +1.5 micro C; r_{21} = 3 cm.

Therefore, $F_{21} = (9 \times 10^9$ N.m^2.C$^{-2}) \times [((+0.2 \times 10^{-6}) \times (+1.5 \times 10^{-6})) / 3^2] = 0.0003$ N

For $F_{31:}$

Let $F_1 = F_{21} = F_{31} = k \times [(q_3 \times q_1) / r^2]$, given F is electrostatic force, k = Coulomb's constant or electrostatic constant, which is to 9×10^9 N.m^2.C^{-2}, $q_{3\,,}$ q_1 = charges, and r = distance of separation between charges 3 and 1.

So, $F_1 = F_{31} = k \times [(q_3 \times q_1) / r^2_{31}]$, where k = 9×10^9 N.m^2.C^{-2}; q_3 = -0.2 micro C; q_1 = +1.5 micro C; r_{31} = 5 cm.

Therefore, $F_{31} = (9 \times 10^9$ N.m^2.C$^{-2}) \times [((-0.2 \times 10^{-6}) \times (+1.5 \times 10^{-6})) / 3^2] = -0.000108$ N

(d) Using Trigonometric Functions: Sin and Cos

For F_{21}:

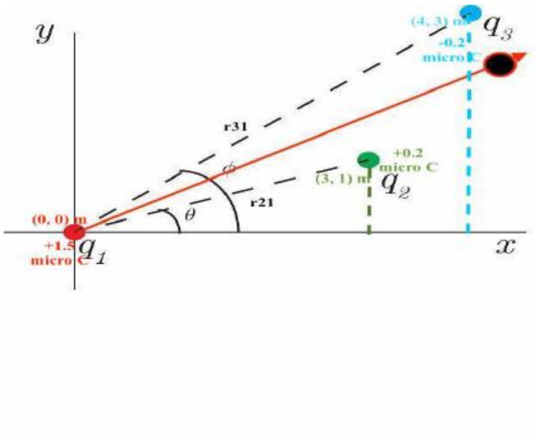
F_{21x} = (0.0003 N)cos 45.0° = 0.000212 N
F_{21y} = (0.0003 N)sin 45.0° = 0.000212 N

For F_{31}:

F_{31x} = (-0.000108 N)cos 45.0° = -0.000076368 N
F_{31y} = (-0.000108 N)sin 45.0° = - 0.000076368 N

Therefore, $F_{net1x} = F_{21x} + F_{31x}$ = 0.000212 N + (-0.000076368 N) = 0.000288368

Therefore, $F_{net1y} = F_{21y} + F_{31y}$ = 0.000212 N + (- 0.000076368 N) = 0.000288368



The red line is the direction of the force from q_2 on q_1 and the force from q_3 on q_1.

As part of your solution, you should write equations with variables as well as numerical values for each of the following quantities

$r_{21} =$
$\theta =$
$F_{21} =$
$F_{21\,x} =$
$F_{21\,y} =$

$r_{31} =$
$\phi =$
$F_{31} =$
$F_{31\,x} =$
$F_{31\,y} =$

$F_{\text{net 1}\,x} =$
$F_{\text{net 1}\,y} =$

r_{21} = 3 cm
θ = 45°
F_{21} = 0.0003 N
F_{21x} = 0.000212 N
F_{21y} = 0.000212 N

r_{31} = 5 cm
ϕ = 45°
F_{31} = -0.000108 N
F_{31x} = -0.000076368 N
F_{31y} = -0.000076368 N

F_{net1x} = 0.000288368
F_{net1y} = 0.000288368

Scan or take a picture of your solution and paste it into this Word document here.
4) Open the website: https://www.geogebra.org/m/eFE9ngHV. This app lets you adjust the charges and positions of three point charges and automatically generates the forces on each of the three charges. Make the charges and positions match those above and compare the answer given by the app to your answer above. Take a screen shot of your GeoGebra app and paste it into this document here.5) Consider a system of three charges on the *x* axis as follows

$$q_1 = +0.2\ \mu\text{C located at } (0\text{ cm}, 0\text{ cm})$$
$$q_2 = +0.8\ \mu\text{C located at } (6\text{ cm}, 0\text{ cm})$$
$$q_3 = +0.1\ \mu\text{C at an unknown location}$$

Your job is to find the location or locations on the *x* axis for charge q_3 such that the total force on q_3 is zero. Answer parts a, b, and c qualitatively before employing GeoGebra. **(DONE)**

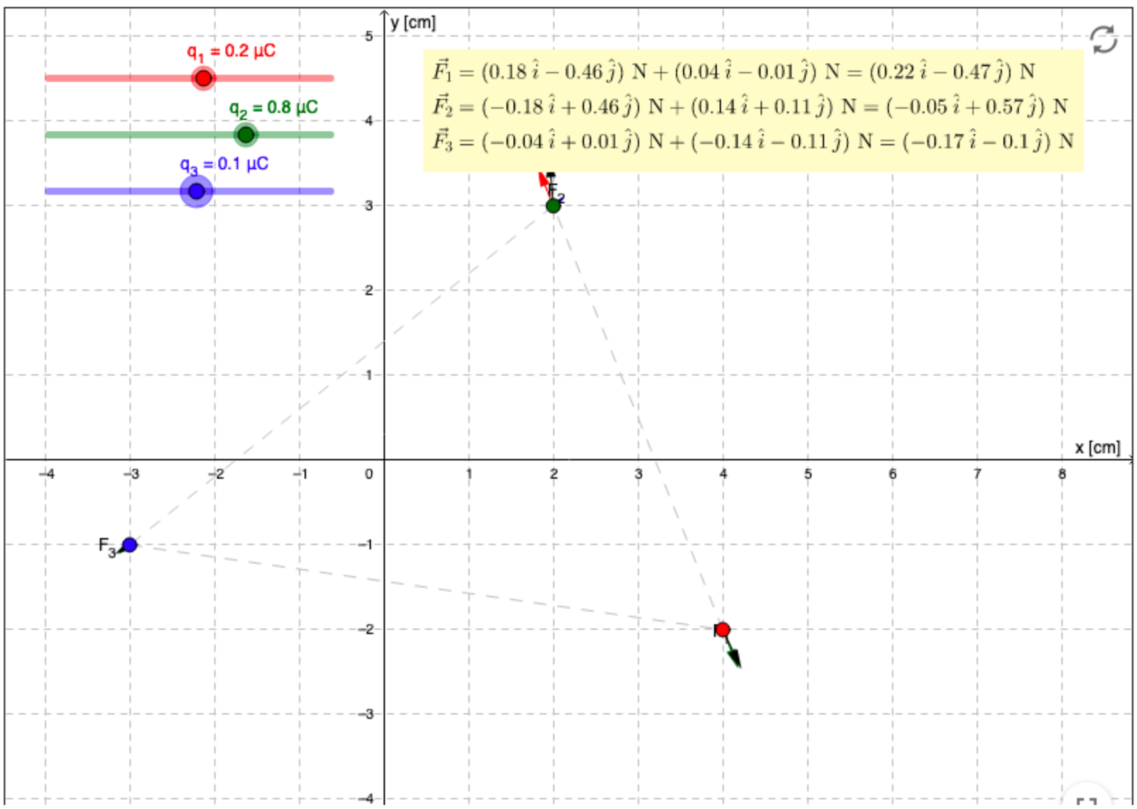
a. Do you expect to find a location to the left of both charges ($x < 0$ cm), where the total force on q_3 is zero? Why or why not?
   Yes, I expect to find a location to the left of both charges (x < 0 cm) where the total force on q_3 is zero because at +0.1 micro C, the total force of q_3 is going to Southwest or toward the third Cartesian plane.

b. Do you expect to find a location in between the two charges (0 cm < x < 6 cm), where the total force on q_3 is zero? If so, should it be closer to q_1 or closer to q_2? Why?
Yes, I expect to find a location in between the two charges (0 cm < x < 6 cm) where the total force on q_3 is zero because at +0.1 micro C, the total force of q_3 is either closer to q_1 or q_2 or much closer to q_2 than q_1 as the total force of q_3 gets closer to zero.

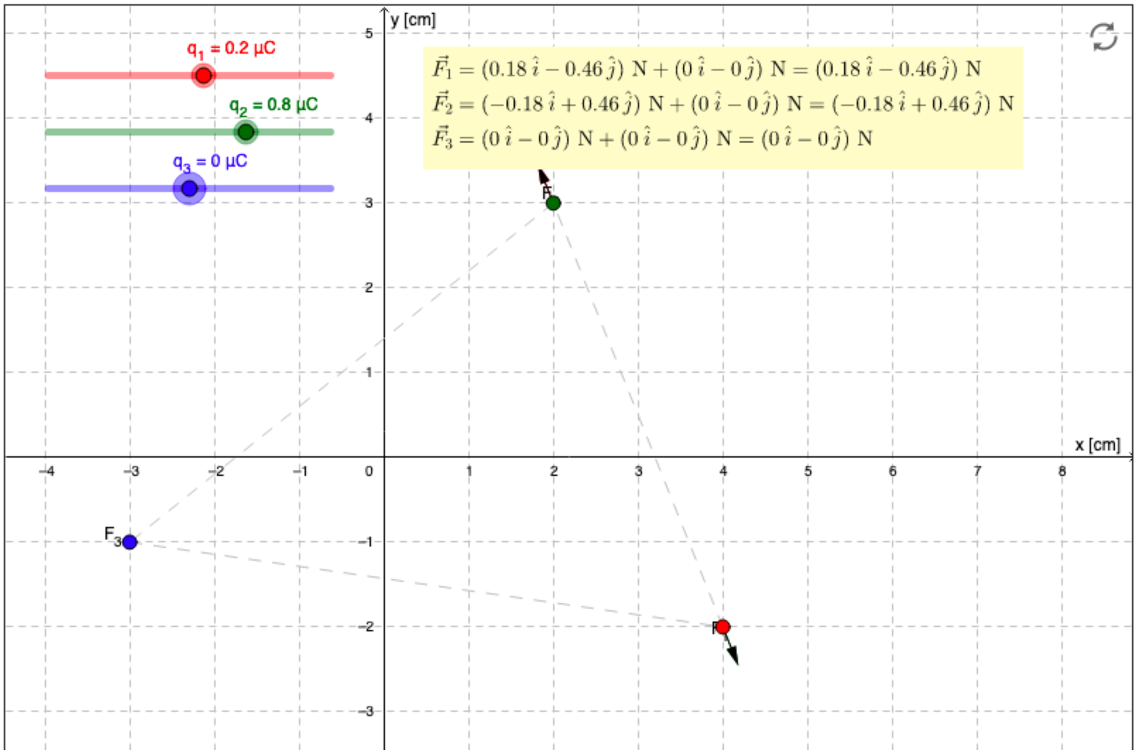
c. Do you expect to find a location to the right of both charges (x > 6 cm), where the total force on q_3 is zero? Why or why not?
No, I do not expect to find a location to the right of both charges (x > 6 cm) where the total force on q_3 is zero because at +0.1 micro C, the total force of q_3 is going to Northwest or toward the second Cartesian plane.

d. Adjust the charges on the GeoGebra website app to match this configuration. Move charge q_3 around to look for positions where the net force on it is zero. Take a screen shot of all such locations and paste them in here. Do they match your expectations above?

i. q_3 is equal to +0.1 micro C



ii. q_3 is equal to 0.0 micro C



Yes, both graphs match my expectations on parts a, b and c.

6) Repeat step 5 (all of parts a-d) with this new configuration of charges

$$q_1 = +0.2\ \mu\text{C located at } (0\text{ cm},\ 0\text{ cm})$$
$$q_2 = -1.8\ \mu\text{C located at } (6\text{ cm},\ 0\text{ cm})$$
$$q_3 = +0.1\ \mu\text{C at an unknown location}$$

Your job is to find the location or locations on the x axis for charge q_3 such that the total force on q_3 is zero. Answer parts a, b, and c qualitatively before employing GeoGebra. **(DONE)**

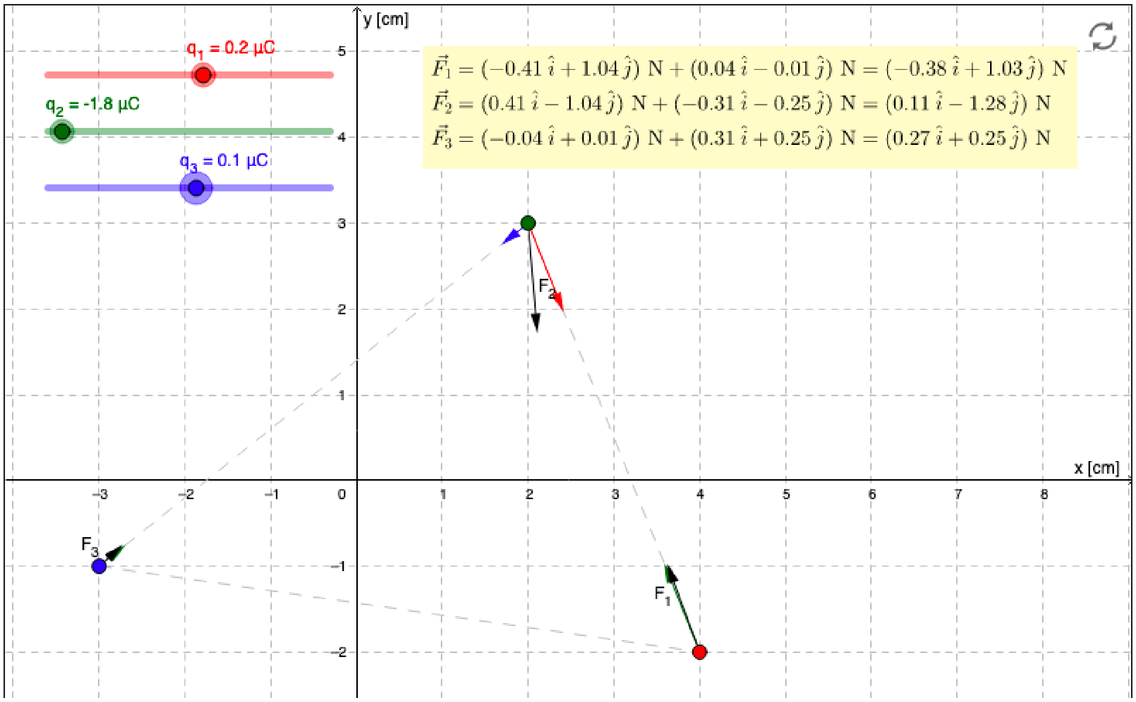
a. Do you expect to find a location to the left of both charges ($x < 0$ cm), where the total force on q_3 is zero? Why or why not?
Yes, I do not expect to find a location to the left of both charges (x < 0 cm) where the total force on q_3 is zero because at +0.1 micro C, the total force of q_3 is going to Northwest or toward the first and second Cartesian plane.

b. Do you expect to find a location in between the two charges (0 cm < x < 6 cm), where the total force on q_3 is zero? If so, should it be closer to q_1 or closer to q_2? Why?
Yes, I expect to find a location in between the two charges (0 cm < x < 6 cm) where the total force on q_3 is zero because at +0.1 micro C, the total force of q_3 is closer to q_2 than q_1 as the total force of q_3 gets closer to zero.

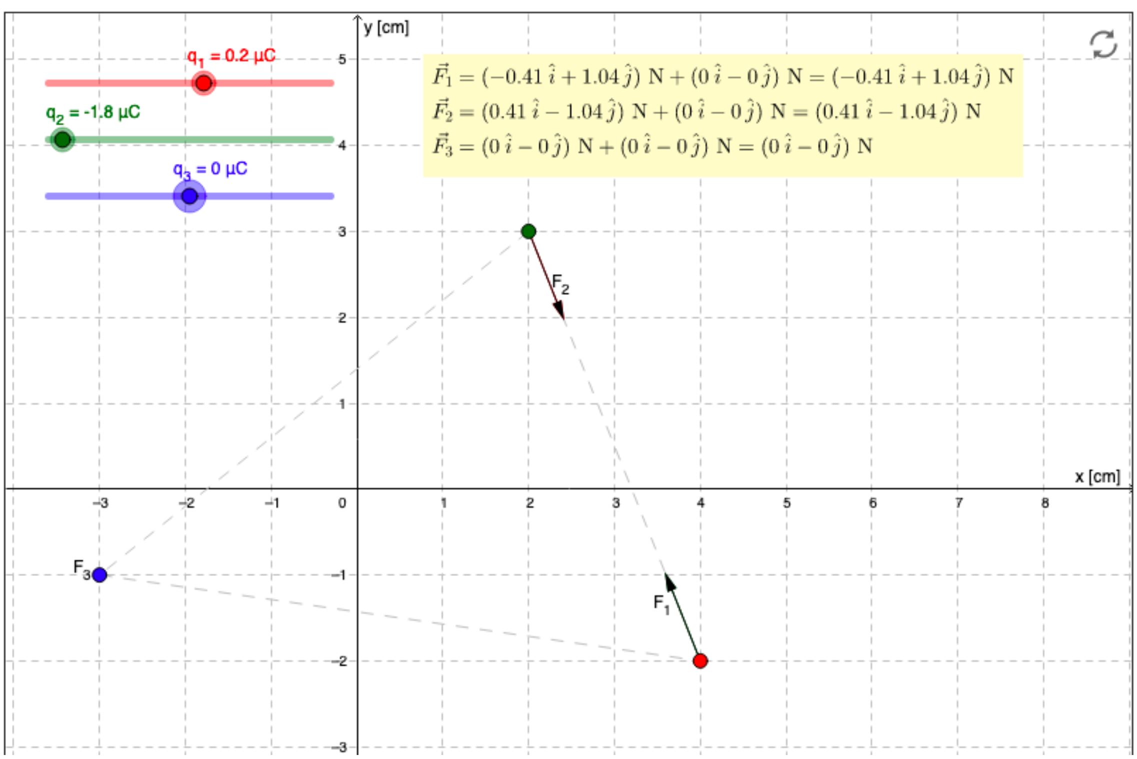
c. Do you expect to find a location to the right of both charges (x > 6 cm), where the total force on q_3 is zero? Why or why not?
Yes, I do expect to find a location to the right of both charges (x > 6 cm) where the total force on q_3 is zero because at +0.1 micro C, the total force of q_3 is going to Northwest or toward the first and/or second Cartesian plane.

d. Adjust the charges on the GeoGebra website app to match this configuration. Move charge q_3 around to look for positions where the net force on it is zero. Take a screen shot of all such locations and paste them in here. Do they match your expectations above?

i. q_3 is equal to +0.1 micro C



ii. q_3 is equal to 0.0 micro C



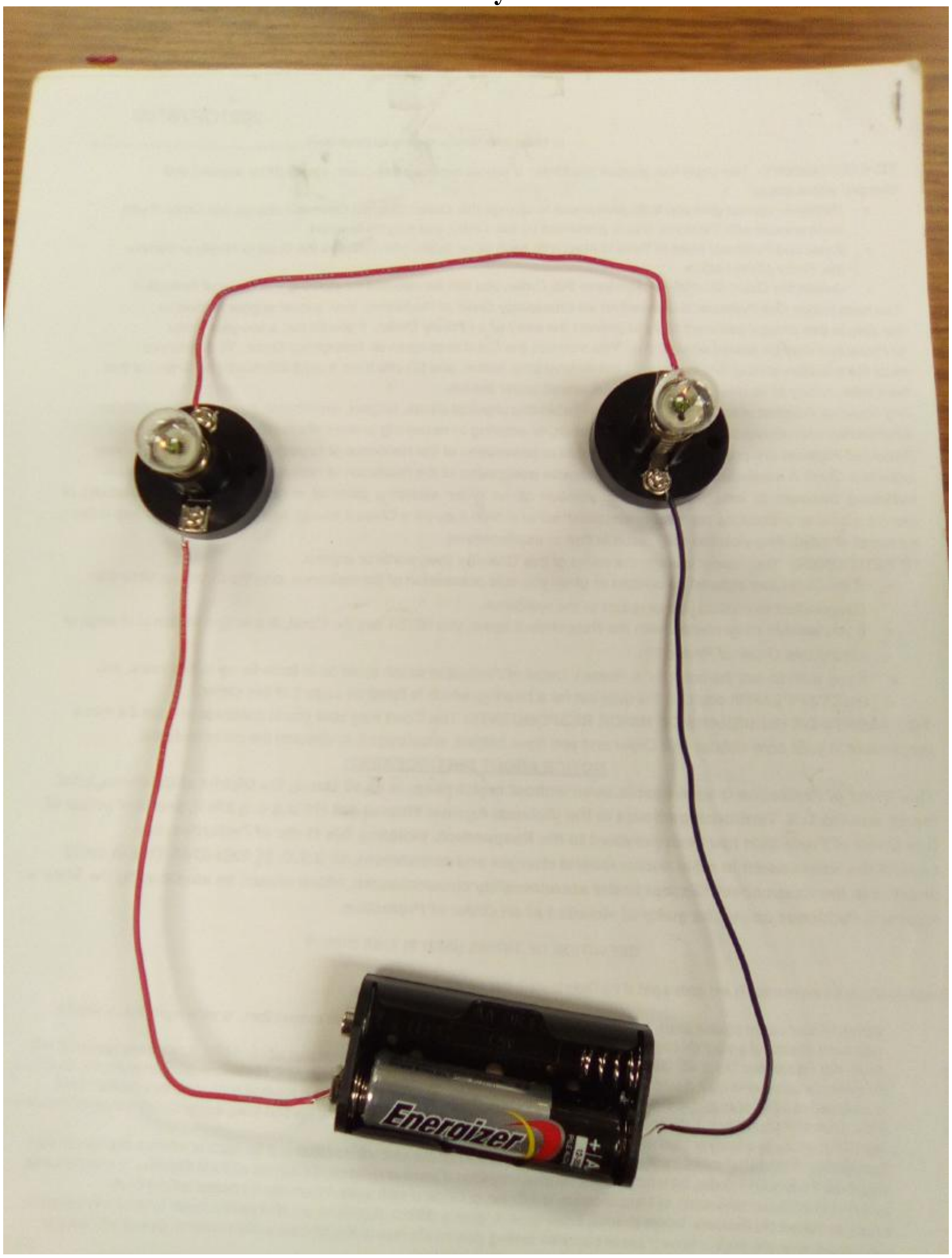
Yes, both graphs match my expectation on parts a, b and c.

7) Save this document as a PDF file and post it. **(DONE)**

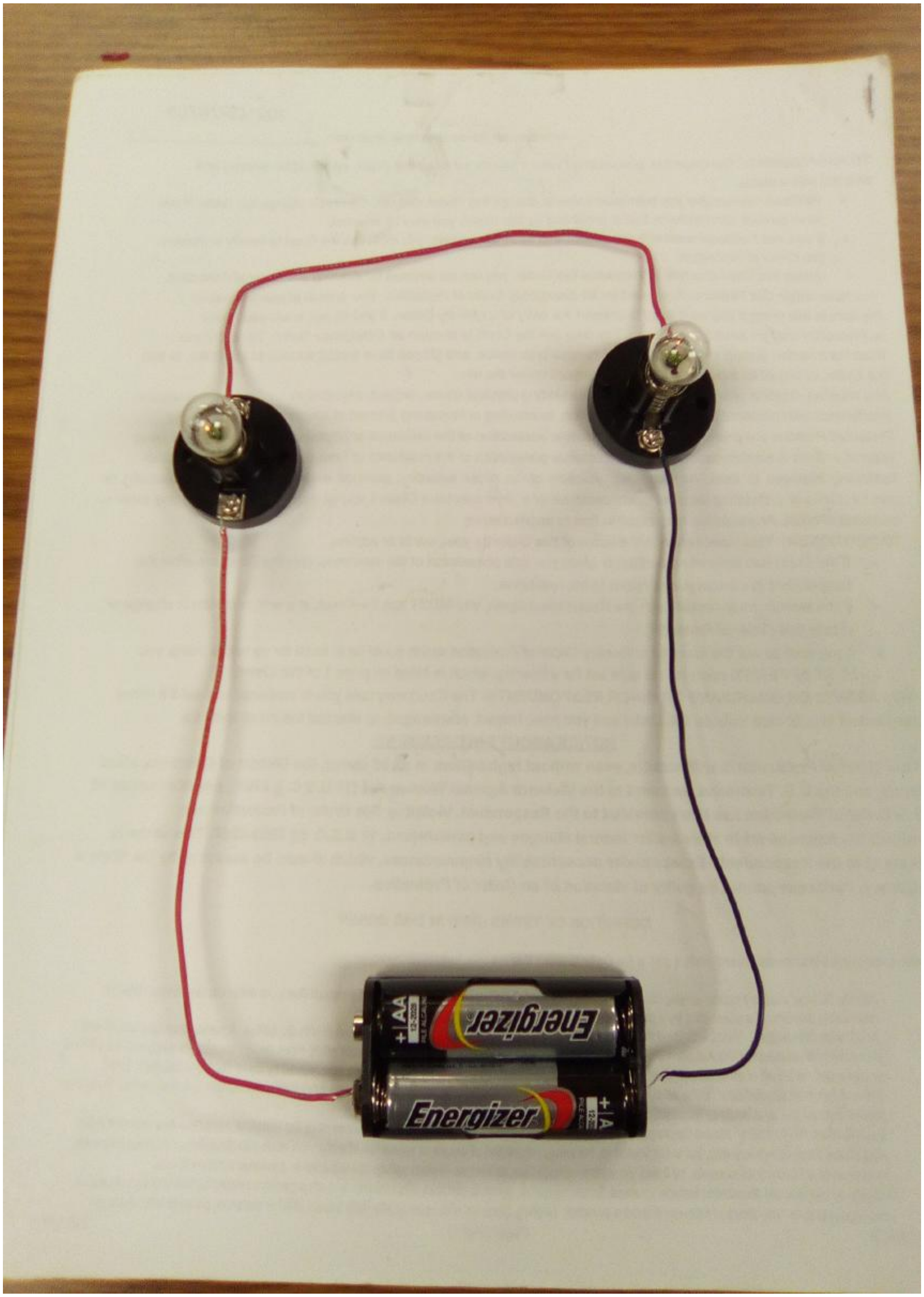
Name: Jerico Matias Cruz **October 30, 2021**
PHYS 236 – Fall 2021 Prof. Schmitz

<u>Series and Parallel Circuits Lab</u>

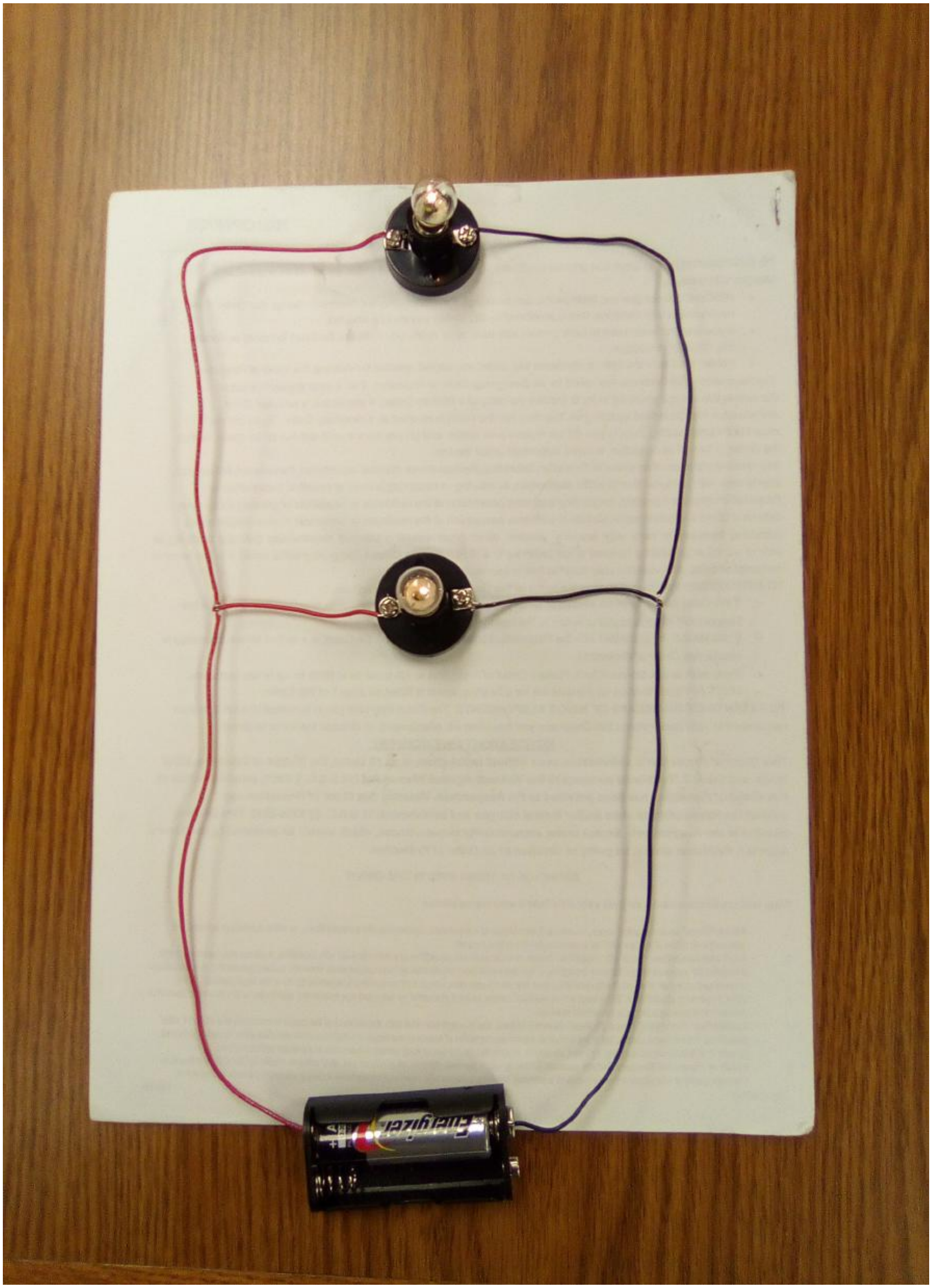
Part I. Series Circuit with One-1.5 Volt AA Battery



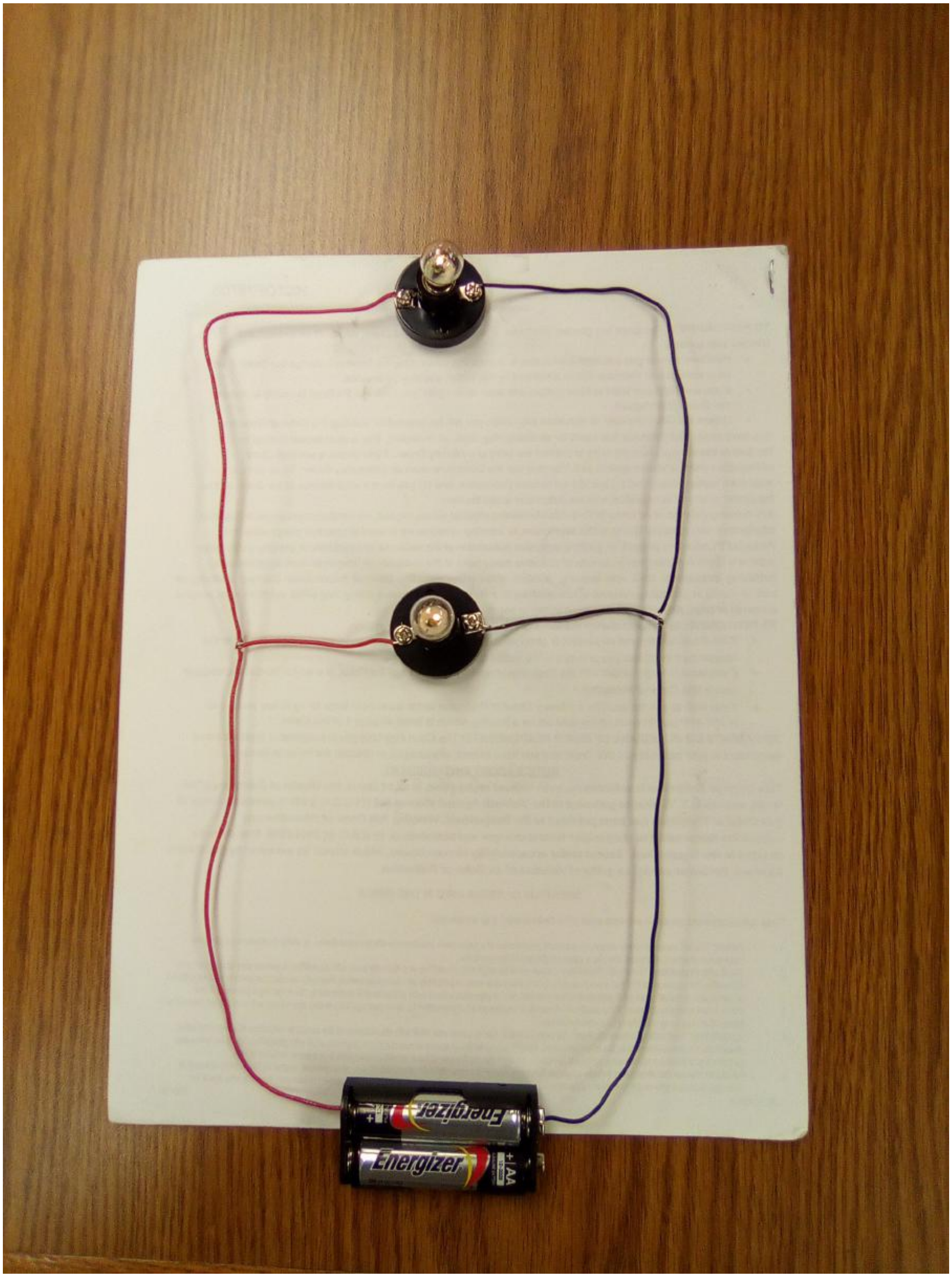
Part II. Series Circuit with Two-1.5 Volt AA Batteries



Part III. Parallel Circuit with One-1.5 Volt AA Battery



Part IV. Parallel Circuit with Two-1.5 Volt AA Batteries



Part V. Instructions & Questions

1. Arrange bulbs in Series and Parallel Circuits, including pictures of each set-up.

   Please review Parts I, II, III, and IV about the arrangement of bulbs in Series and Parallel Circuits, including pictures of each set up.

2. In which set-up are the bulbs brighter?

   Parallel circuit's bulbs are brighter than Series circuit's bulbs.

3. Try for both Series and Parallel, if one bulb is removed will the other go out?

   For both Series and Parallel circuits, if one bulb is removed, the other bulb will never go out.

4. Extra Credit: If you have two batteries, can the batteries be arranged in Series and Parallel.

   Batteries can be arranged in Series and Parallel circuits.

5. Which is brighter? Explain why this is.

   Parallel circuit's batteries are brighter for both one and two bulbs, while Series circuit's batteries for both one and two bulbs are not brighter as Parallel circuit's batteries. Therefore, Parallel circuit batteries are considered isolated systems with their own charges.

Reference

Home: electronicals. c2016-2021. Skokie (IL): American Science & Surplus; [accessed 2021 Oct 25]. https://www.sciplus.com/Communications-Electronics-h

Name: Jerico Matias Cruz **October 30, 2021**
PHYS 236 – Fall 2021 Prof. Schmitz

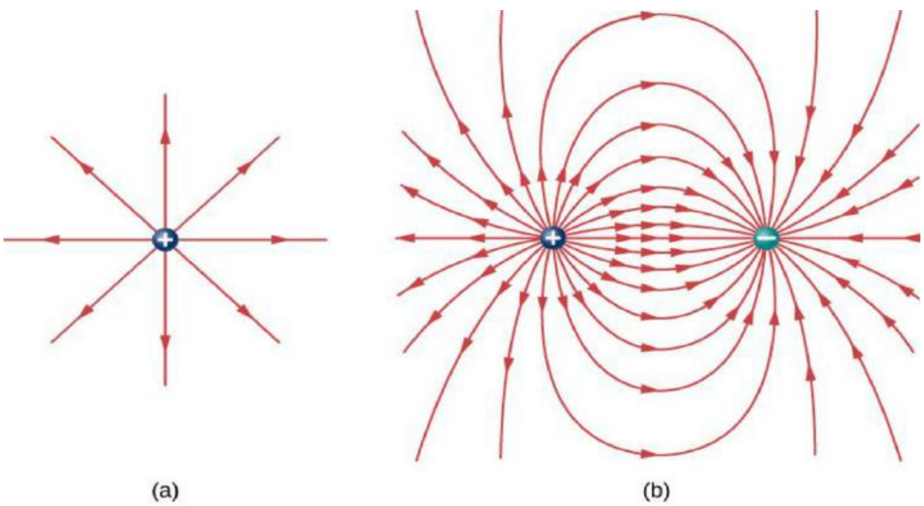
Charges and Fields

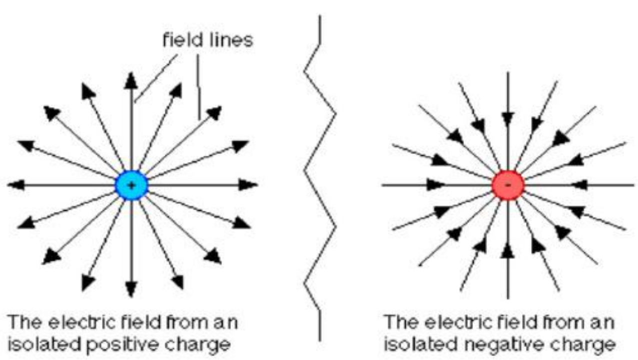
I. Electric Field due to a Point Charge

Concept: the electric field due to a point charge is given by

$$\vec{E} = \frac{Kq}{r^2}\,\widehat{u_r}$$

An electric field can be visualized on paper by drawing lines of force, which give an indication of both the size and the strength of the field. Lines of force are also called field lines. Field lines start on positive charges and end on negative charges





Procedure

Go to the web site

https://phet.colorado.edu/en/simulation/charges-and-fields

Once you are at the site "charges and fields" Click "play".

The simulation contain the following items

- **A positive charge particle of 1 nC = 10^{-9} C**
- **A negative charge particle of 1 nC = 10^{-9} C**
- **A sensor that shows the value of the Electric Field at any point in space in V/m**
- **A distance measuring tape in cm.**
- **A grid that shows the direction of the electric field.**

I. Measurement of magnitude and direction of the Electric field due to a point charge

The electric field for a point charge is given by

$$\vec{E} = \frac{Kq}{r^2}\widehat{u_r} \quad \text{---------} \quad (*)$$

Where the constant k is given by K = 8.99 x 10^9 Nm^2/C^2

For the simulation q = 10^{-9} C. The magnitude of the electric field is going to be measured at different directions and different distance r from the point charge. Note that the sensor in the simulation gives the value of E in Volt/meter (V/m). It can be shown that 1 V/m= 1 N/C.

Notice the scale of 1 m in the grid in the lower left corner.

Let's denote the value for E obtained by the equation E = Kq/r^2 u_r as E_1, actually is an

experimental value because you need to measure r. Denote the value obtained by the sensor as E_2. Then calculate the % difference using the formula below

Note:

Percent difference is practically the same as percent error, only instead of one "true" value and one "experimental" value, you compare two experimental values. The formula is:

$$\%\ Difference = \frac{|E_1 - E_2|}{\frac{1}{2}(E_1 + E_2)} * 100 \quad \text{--------} (**)$$

Procedure

1. Measure the Electric Field of the point charge in a direction of 0°

Move the positive point charge to the center of the plane. Assume this position as the origin.

Click in the boxes in the upper right side to activate the electric field direction, voltage, values, grid.

Use the sensor (yellow circle) to measure the Electric field at different points along the x axis. The sensor gives the value of the electric filed in V/m

Complete the table below

Table 1: Electric Field of the Point Charge in a Direction of 0°.

X (m) Distance from the positive test charge	E_2 using the sensor V/m	$\lvert E_1 \rvert$ from equation (*) in N/m	% error from equation (**)
0.5	34.2	35.96	5.01
1	9.31	8.99	-3.49
1.5	4.35	3.99	-8.63
2.0	2.60	2.247	-4.72
2.5	1.92	1.438	-28.5
3.0	1.55	0.998	-43.3
3.5	1.34	0.734	-58.4
4.0	1.77	0.562	-103

2. Measure the Electric Field of the point charge in a direction of 90° with respect to +x direction

Table 2: Electric Field of the Point Charge in a Direction of 90°.

Y (m) Measured vertically from the positive charge	E_2 using the sensor (V/m)	$\lvert E_1 \rvert$ from equation (*) in N/m	% error from equation (**)
0.5	33.6	35.96	+6.78
1	8.82	8.99	+1.9

1.5	3.95	3.99	+1.00
2.0	2.19	2.247	+12.4

3. Measure the Electric Field of the point charge in a direction of 45° with respect to + x direction.

Use the measuring tape to verify the value of r. At 45°, follow the diagonal of the square grid

Table 3: Electric Field of the Point Charge in a Direction of 45° with Respect to + X Direction.

r (m)	E_2 using the sensor V/m	$\lvert E_1 \rvert$ from equation (*) in N/m	% error from equation (**)
0.705	17.9	18.08	+1.00
1.41	4.39	4.58	+4.23
2.12	2.11	2.00	-5.35
2.82	1.48	1.13	-26.8

4. Measure the Electric Field of the point charge in a direction of 45° with the negative x direction.

Use the measuring tape to verify the value of r. At 45°, follow the diagonal of the square grid.

Table 4: Electric Field of the Point Charge in a Direction of 45° with the - X Direction.

r (m)	E_2 using the sensor V/m	$\lvert E_1 \rvert$ from equation (*) in N/m	% error from equation (**)
0.705	14.0	18.08	+25.4
1.41	4.77	4.58	-4.06
2.12	2.34	2.00	-15.7
2.82	1.48	1.13	-26.8

Analysis

Do Excel plots

Plot E_2 vs distance x. You have to make two plots, one for the results of part 1 and one for part 2. The plots must be a scatter plot. Do not joint the points with a curve. Below is an example of the Excel plot

Figure 1. Part 1 Data: E_2 from the Sensor (N/m) vs. X (m).

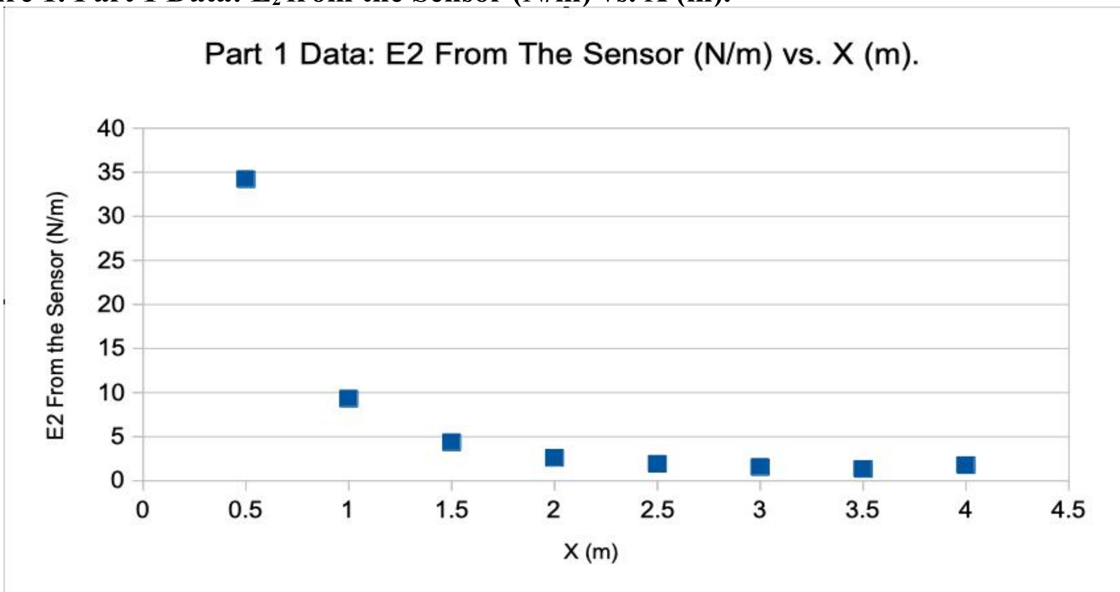
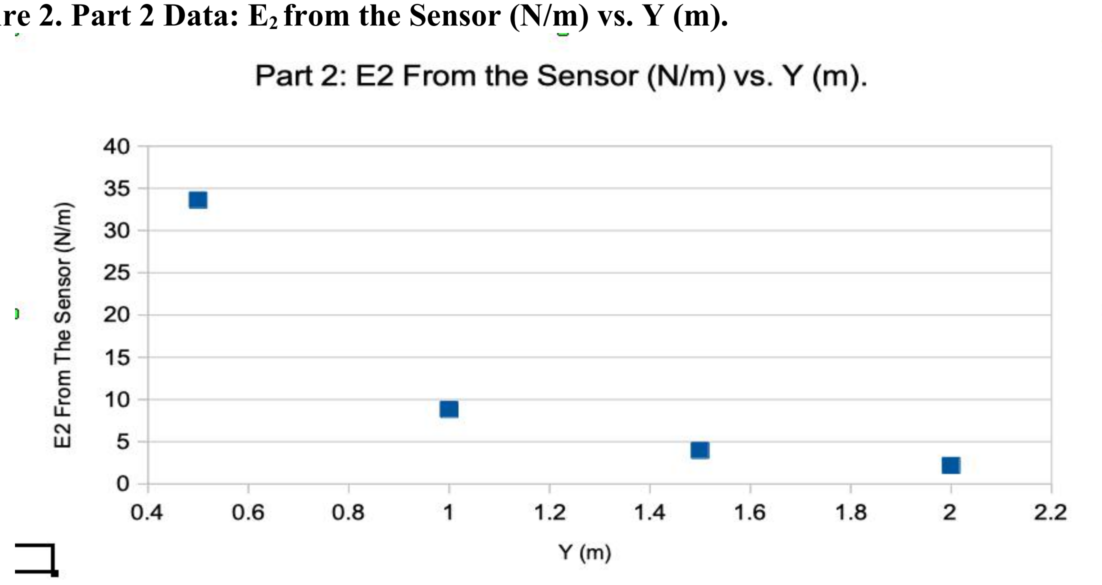


Figure 2. Part 2 Data: E_2 from the Sensor (N/m) vs. Y (m).



Questions

1. Do you obtain the same values for the electric field at directions of 0° and 90° for the same distance?

$$\vec{E} = \frac{Kq}{r^2}\widehat{u_r}$$

Yes, I obtained the same numerical values for Parts 1 and 2 E_1 data at directions of 0° and 90° for the same distance in this experimental condition or set-up because the calculation indicated that I used the same numerical values for distance (r), Coulomb constant (k), and charge of the point of origin, positively charge particle to calculate E_1 using the formula above highlighted in yellow. On the other hand, for Parts 1 and 2 E_2 data in this experimental condition or set-up, I used the Sensor on the website to identify or find the numerical value of E_2 without performing calculation or utilizing the formula above highlighted in yellow. **I did not obtain the same numerical values for E_2, but there is a small variation with numerical values for Parts 1 and 2 E_2 data at directions of 0° and 90° for the same distance.** See Figure 1 and Figure 2 to visualize the numerical values for Parts 1 and 2 E_1 data at directions of 0° and 90° for the same distance.

2. Do you obtain the same value of the electric field for symmetric points at a direction of 45° with positive x and at a direction of 45° with negative x?

$$\vec{E} = \frac{Kq}{r^2}\widehat{u_r}$$

Yes, I obtained the numerical values for E_1 for symmetric points at a direction of 45° with positive x and at a direction of 45° with negative x using the formula highlighted in yellow to calculate E_1, including the same numerical values for distance (r), Coulomb constant (k), and charge of the point of origin, positively charge particle. On the other hand, for Parts 3 and 4 E_2 data in this experimental condition or set-up, I used the Sensor on the website to identify or find the numerical value of E_2 without performing calculation or utilizing the formula above highlighted in yellow. I did not obtain the same numerical value for E_2, but there is a small variation with numerical values for Parts 3 and 4 E_2 data or symmetric points at a direction of 45° with positive x and at a direction of 45° with negative x.

3. Verify that the magnitude of the electric field must be the same at points at the same distance from the charge. From your data from part 1 and 2 complete the table below

Table 5. Data from Part 1 and Part 2 to Complete the Table

X (m)	E_2 using the sensor (V/m) from part 1	Y (m)	E_2 using the sensor (V/m) From part 2	% error difference using E_2 for the X and E_2 for the Y direction from equation (**)
0.5	34.2	**0.5**	33.6	-1.76
1	9.31	**1**	8.82	-5.405
1.5	4.35	**1.5**	3.95	-9.397
2.0	2.60	**2.0**	2.19	-17.11

4. Write a conclusion.

$$\% \, Difference = \frac{|E_1 - E_2|}{\frac{1}{2}(E_1 + E_2)} * 100$$

To find the percent error difference between E_2 for X (m) and E_2 for Y(m), use the formula above. As stated above from previous answer on Question No. 1, I did not obtain the same numerical values for E_2 for X(m) and E_2 for Y(m), but there is a small variation with numerical values for Parts 1 and 2 E_2 data at directions of 0° and 90° for the same distance as stated on the result from the calculation of the percent error difference between E_2 for X (m) and E_2 for Y(m). See Figure 1 and Figure 2 to visualize the numerical values and percent error different between E_2 for X (m) and E_2 for Y(m) for Parts 1 and 2 E_2 data at directions of 0° and 90° for the same distance. Therefore, the percent error difference between E_2 for X (m) and E_2 for Y(m) might have occurred when plotting the Sensor into the grid for a specific distance for E_2 for X (m) and E_2 for Y(m).

II. Electric Field due to two point charges.

To find the electric filed of two point charges at a given point in space, apply the principle of superposition.

$$\vec{E}_{total} = \vec{E}_1 + \vec{E}_2 \; ; \qquad \text{------(***)}$$

At a given distance r; E total is given by

$$\vec{E}_{total} = \frac{Kq1}{r^2}\widehat{u_r} + \frac{Kq2}{r^2}\widehat{u_r} \quad \text{--------(***)}$$

In the simulation the numerical values of q_1 equal q_2 are equal, and keep in mind that q2 is negative

Procedure:

Locate both charges positive and negative separated a distance of 4 m. Assume the origin is located at the position of the positive charge and place the positive charge to the left of the negative charge

Calculate the coulomb force for a distance of 4 m

$$|Fcoulomb| = \frac{Kq1q2}{r^2} = \underline{\hspace{4cm}} \text{ N}$$

| Fcoulomb | = (**8.99 x 10^9 Nm^2/C^2**)(1.00 x **10^{-9} C)(1.00 x 10^{-9} C) / 4^2** = **0.562 N**

Find the total electric field of the two point charges along the axis that connects the charges. Remember the origin is located at the positive charge, and positive x is the direction to the right of the positive charge. Denote q_1, r_1 for the positive charge and q_2 and r_2 for the negative charge

Complete the table:

Table 6. Calculation of Total Electric Field of the Two Point Charges along the X-Axis that Connects the Charges.

r_1 (m)	E_1 (N/C) From equation (*)	Direction of E_1 +X or -X	.r_2 (m)	E_2 (N/C) From equation (*)	Direction of E2 +X or -X	E total from equation *** (N/C) Direction +X or -X
1	8.99	+X	**1**	8.99	-X	17.98
2	2.247	+X	**2**	2.247	-X	4.49
3	0.998	+X	**3**	0.998	-X	1.996
5	0.359	+X	**5**	0.359	-X	0.718
6	0.249	+X	**6**	0.249	-X	.498
7	0.183	+X	**7**	0.183	-X	.366
-1	8.99	-X	**-1**	8.99	+X	17.98
-2	2.247	-X	**-2**	2.247	+X	4.94

Complete the table using the sensor

Table 7. Total Electric Field of the Two Point Charges along the Axis that Connects the Charges Using the Sensor Empirical Data and Table 6 Calculated Data.

.r1 (m)	E_{total} using the sensor in V/m Direction +X or -X	E_{total} from the previous table (N/C)	% error difference from equation (**)
1	9.19	17.98	+64.7
2	2.45	4.49	+58.8
3	1.31	1.996	+41.5
5	0.80	0.718	-10.8
6	1.02	.498	-68.8
7	0.76	.366	-69.9
-1	8.62	17.98	+70.4
-2	2.50	4.94	+65.6

$$\% \, Difference = \frac{|E_1 - E_2|}{\frac{1}{2}(E_1 + E_2)} * 100 \qquad \text{---------(**)}$$

Questions:

1. **The % error difference increase, decrease or is random as function of distance r.**

   I calculated the percent difference using the E_{total} from the previous table (N/C) and Etotal using the Sensor in V/m, Direction +X or -X. The percent error difference decreases as the distance, .r1 (m), of Sensor moves from positive quadrant (x-axis) of the Cartesian plane, and then increases as distance, .r1 (m), of Sensor moves to negative quadrant (x-axis) of the Cartesian plane.

2. **Show that 1 V/m is equal to 1 N/C. Use the concept that 1 V = 1 Joule/C**

   Suppose W = F x *d*s = qE x *d*s, where W = Work, F = Force, *d*s = infinitesimal displacement vector, q = point of charge, and E = electric field.

Let W = - change in U_E, U_E = electric potential energy for the charge of the field system and given that this is a closed and isolated system.

Let change in $U_E = - q \int_A^Z E \times ds$, where points A to Z change in electric potential energy of the system.

However, neither force qE nor the line integral of the system does not depend on points A to Z.

So, $U_E = 0$, given that the position of q in the field system is relative to the configuration of the system, meaning the q can be positively or negatively charge, and not equal to zero.

Therefore, $V = U_E/q$, where V = electric potential of the field system.

Therefore, potential difference or change in $V = V_A - V_Z$ = change in $U_E/q = - q \int_A^Z E \times ds$,

where $V_A - V_Z$ = potential difference from points A to Z in the electric field when the q moves between the points of the field system.

Therefore, W = q x change in V, if and only if work is performed by external factor without performing kinetic energy, but moves q through the electric field, while keeping the velocity constant in the field system.

Therefore, electric potential is a measure of potential energy per unit charge; both electric potential and potential difference's standard unit is 1 V = 1 J / C, where V = volt, and J/C = Joules per Coulomb.

Therefore, potential difference also has units of electric field, which multiplies to distance with standard unit of N/C, where N/C = Newton/Coulomb.

Therefore, by definition, electric field is a measure of the rate of change of the electric potential with respect to position.

Therefore, electric field can be expressed to 1 N/C = 1 V/m, where V/m = volts per meter.

3. Conclusions.

Using the concept of electric at a point charge, $E = kq/r^2$, where E = electric field, k = Coulomb's constant, q = point of charge, and r = a distance of a point charge or a separation distance between two points of charges. In this experiment, the origin of the point of charge was always the positive charge, whether the electric field's empirical data or numerical values, were calculated, or collected using the Sensor, as stated from the charges and fields' website: https://phet.colorado.edu/en/simulation/charges-and-fields. Therefore, the electric field's standard unit from the calculation using the $E = kq/r^2$, which used N/C, was similar to the electric field from the Sensor, which used V/m.

Reference

Phet Interactive Simulations: charges and fields. c2021. Boulder (CO): University of Colorado Boulder; [accessed 2021 Oct 30]. https://phet.colorado.edu/sims/html/charges-and-fields/latest/charges-and-fields_en.html

Submission receipt

CCC OIT - No Reply <cohelpdesk@ccc.edu>
Sun 10/3/2021 2:44 PM
To: Jerico Cruz <jcruz156@student.ccc.edu>

Jerico Cruz

This email is to confirm that your submission to assignment folder Test One was successful.

Submission ID: 1838067
Received: Sunday, October 3, 2021 2:44 PM CDT
Org Unit: Fall 2021 PHYSICS 236 OQS WR
File(s): JericoMatiasCruz-PhysicsEngineeringII-TestOne.pdf (3350 KB)

Submission receipt

CCC OIT - No Reply <cohelpdesk@ccc.edu>

Sun 10/31/2021 9:57 PM

To: Jerico Cruz <jcruz156@student.ccc.edu>

Jerico Cruz

This email is to confirm that your submission to assignment folder Test Two was successful.

Submission ID: 1941576
Received: Sunday, October 31, 2021 9:57 PM CDT
Org Unit: Fall 2021 PHYSICS 236 OQS WR
File(s): JericoMatiasCruz-EngineeringPhysicsII-TestTwo.pdf (5787 KB)

Submission receipt

CCC OIT - No Reply <cohelpdesk@ccc.edu>
Wed 11/24/2021 7:12 PM
To: Jerico Cruz <jcruz156@student.ccc.edu>

Jerico Cruz

This email is to confirm that your submission to assignment folder Test Three was successful.

Submission ID: 2028187
Received: Wednesday, November 24, 2021 7:12 PM CST
Org Unit: Fall 2021 PHYSICS 236 OQS WR
File(s): JericoMatiasCruz-EngPhysII-Test3.pdf (5892 KB)

Submission receipt

CCC OIT - No Reply <cohelpdesk@ccc.edu>

Wed 9/29/2021 6:05 PM

To: Jerico Cruz <jcruz156@student.ccc.edu>

Jerico Cruz

This email is to confirm that your submission to assignment folder Electrostatics lab was successful.

Submission ID: 1827377
Received: Wednesday, September 29, 2021 6:05 PM CDT
Org Unit: Fall 2021 PHYSICS 236 OQS WR
File(s): JericoMatiasCruz-Electrostatics lab rev1. 2.pdf (262 KB)

Submission receipt

CCC OIT - No Reply <cohelpdesk@ccc.edu>
Sat 10/30/2021 1:14 AM
To: Jerico Cruz <jcruz156@student.ccc.edu>

Jerico Cruz

This email is to confirm that your submission to assignment folder Parallel and series lab was successful.

Submission ID: 1937697
Received: Saturday, October 30, 2021 1:14 AM CDT
Org Unit: Fall 2021 PHYSICS 236 OQS WR
File(s): JericoMatiasCruz-Series-Parallel-Lab.doc (5736 KB), JericoMatiasCruz-Series-Parallel-Lab.pdf (3888 KB)

Submission receipt

CCC OIT - No Reply <cohelpdesk@ccc.edu>
Sat 10/30/2021 1:06 AM
To: Jerico Cruz <jcruz156@student.ccc.edu>

Jerico Cruz

This email is to confirm that your submission to assignment folder Charges and Field virtual lab was successful.

Submission ID: 1937690
Received: Saturday, October 30, 2021 1:06 AM CDT
Org Unit: Fall 2021 PHYSICS 236 OQS WR
File(s): JericoMCruz-Charges and Fields virtual lab.doc (754 KB), JericoMCruz-Charges and Fields virtual lab.pdf (321 KB)

[redacted] × +

Inbox (2,696) - jcruz7@neiu.edu - Nmail Mail

https://www.cengage.com/dashboard/#/my-account/orders

Jerico

My Home

Catalog and Study Tools

Rental Options

College Success Tips

Career Success Tips

Help

Give Feedback

CENGAGE

Enter Access Code / Course Key

Search the catalog

Purchase Date: 10/03/2021

Order number: [redacted]486

Shipping Address

Not Applicable

Billing Address

Jerico M. Cruz
5135 N Keating Ave
Chicago IL
US 60630

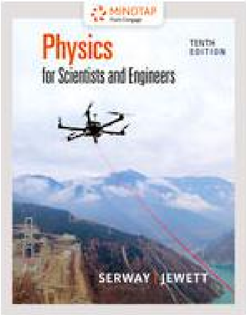
Payment Method

MasterCard
[redacted]

Order Summary

Subtotal:	**$100.00**
Shipping:	**Free**
Estimated Tax*:	**$0.00**
Order Total:	**$100.00**

Inventory fulfilled:



WebAssign Instant Access for Serway/Jewett's Physics for Scientists and Engineers, Single-Term, 10th Edition **$100.00**
Authors: Serway/Jewett
ISBN 13: 978-1-337-69928-0
ISBN 10: 1-337-69928-4
@2019 | Digital |112