First Name:_____   Last Name:_____

L10 – Worksheet – Electrostatics Review

L01 – Electrical Interactions and Electroscopes

Use the following to answer Q1:

An electroscope is charged via induction, per the diagram below.

| Diagram #1 | Diagram #2 | Diagram #3 | Diagram #4 |

Nature of Charge
1 – Positive
2 – Negative
3 – Neutral

Subatomic Particle
4 – Protons
5 – Electrons
6 – Neutrons

Q1: In *Diagram #2*, the net charge at *Point A* is _____**2**_____ due to the movement of _____**5**_____.
        Nature of Charge   *Subatomic Particle*

In *Diagram #4*, the net charge at *Point B* is _____**2**_____.
                                                Nature of Charge

*(Record your **three digit** answer in the Numerical Response boxes below)*

| 2 | 5 | 2 | |

Use the following information to answer Q2-Q3:

Van Der Graff Generator

Metal brush · Pulley · Pith ball · Insulating belt to carry and deliver charge · Insulating supporting column · Motor driven pulley · Metal brush delivering charge from source · Grounded metal base

Q2: In the diagram above, when the Van Der Graff generator is initially turned on, the pith ball will be __*i*__ the dome due to __*ii*__ .
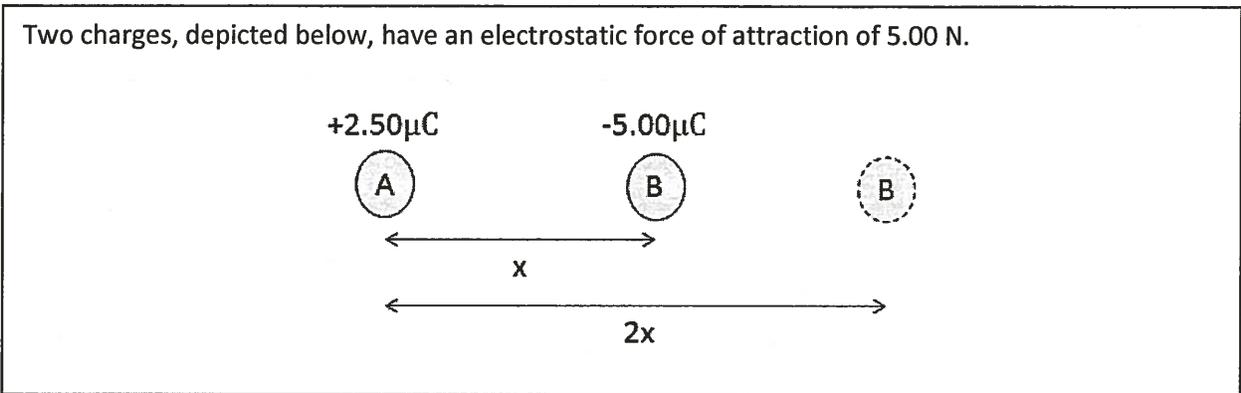
	i.	ii.
A.	attracted to	conduction
B.	attracted to	induction
C.	repelled from	conduction
D.	repelled from	induction

Q3: The moment the Van Der Graff generator is turned on, the left side of the pith ball becomes __*i*__ charged and the right side becomes __*ii*__ charged.

	i.	ii.
A.	positively	positively
B.	positively	negatively
C.	negatively	positively
D.	negatively	negatively

L02 – Coulomb's Law in 1-D

Use the following information to answer Q4-Q5:

Two charges, depicted below, have an electrostatic force of attraction of 5.00 N.

+2.50μC   -5.00μC

(A)   (B)   (B)

←————————→
          X

←——————————————————→
              2x

Q4: If *Charge B* is moved from *x* to *2x*, what is the force of attraction between the two items, measured in Newtons?

*(Record your **three digit** answer in the Numerical Response boxes below)*

| 1 | . | 2 | 5 |

EASY METHOD

$$F = \frac{kq_1q_2}{r^2}$$

$$F_{new} = \frac{k(q_1)(q_2)}{(2r)^2}$$

$$F_{new} = \frac{1}{4}\left(\frac{kq_1q_2}{r^2}\right)$$

$$= \frac{1}{4}(5.00N)$$

$$= 1.25 N$$

HARD METHOD

$$F = \frac{kq_1q_2}{r^2}$$

$$5.00 = \frac{(8.99\times10^9)(2.5\times10^{-6})(5.0\times10^{-6})}{r^2}$$

$$r^2 = 0.022475$$

$$r = 0.1499166643506 \, m$$

$$F_{new} = \frac{(8.99\times10^9)(25\times10^{-6})(5.0\times10^{-6})}{(2 \times 0.1499166643506)^2}$$

$$F_{new} = 1.24\bar{9}$$

$$= 1.25N$$

Q5: At what distance, in meters, will the charges have an electrostatic attraction of 2.00×10^{-3} N?

*(Record your **three digit** answer in the Numerical Response boxes below)*

| 7 | . | 5 | 0 |

$$F = \frac{kq_1q_2}{r^2}$$

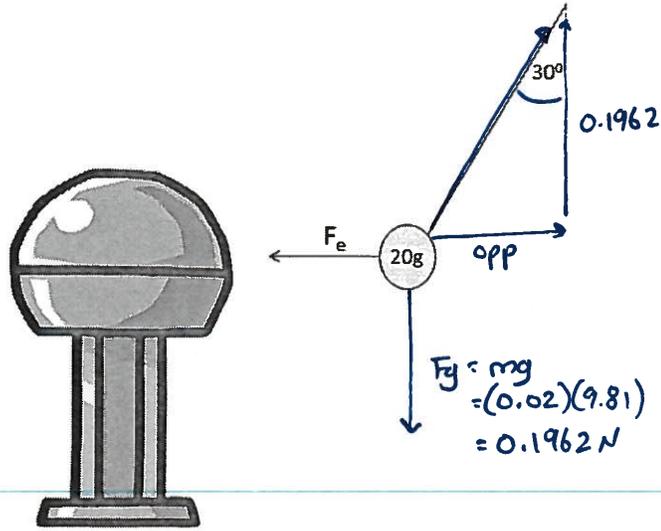$$(2.00\times10^{-3}) = \frac{(8.99\times10^9)(2.5\times10^{-6})(5.0\times10^{-6})}{r^2}$$

$$r^2 = 56.1875$$

$$r = 7.49583217528 \, m$$

$$r \approx 7.50 \, m$$

Use the following information to answer Q6:

A 20g pith ball hanging on an insulated thread is placed near an electroscope, and the following observation is made:

$30°$

0.1962

F_e

20g

opp

$F_y = mg$
$= (0.02)(9.81)$
$= 0.1962 N$

Q6: The electrostatic force of attraction is

(a) 1.13×10^{-1} N
b. 1.96×10^{-1} N
c. 2.27×10^{-1} N
d. 3.40×10^{-1} N

$Tan \theta = \frac{o}{a}$

$Tan \, 30 = \frac{opp}{0.1962}$

$opp = 0.113276122815$

$So \; F_e = 1.13 \times 10^{-1} N$

Use the following information to answer Q7-Q9:

Two conductive spheres are arranged per the diagram below.

50.0 cm

(A)   (B)

m_A = 20.0g m_B = 30.0g

q_A = +1.50µC q_B = -5.00µC

The conductive spheres are momentarily brought into contact, and then returned to their original position. Both items are then released simultaneously.

Q7: The acceleration of *Object B* is

a.) 3.67 m/s² [Right]
b. 3.67 m/s² [Left]
c. 8.99 m/s² [Right]
d. 8.99 m/s² [Left]

(+1.5)   (-5.0)

(-3.5)

(-1.75)   (-1.75)

Fe   Fe
      0.5m
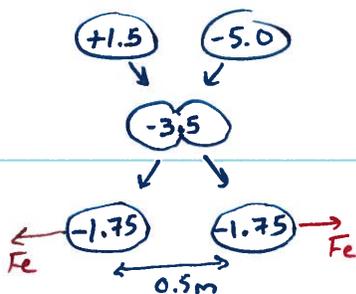
$F_e = \dfrac{kq_1 q_2}{r^2}$

$F_e = \dfrac{(8.99\times10^9)(1.75\times10^{-6})(1.75\times10^{-6})}{(0.5)^2}$

$F_e = 0.1101275$

$a = \dfrac{F_{net}}{m} = \dfrac{0.1101275}{0.03} = 3.67 \text{ m/s}^2 \, [R]$

Repulsive,
so pushed to
the right.

Q8: When predicting the acceleration of *Object B*, state the two physics principles you used, in the order you used them.

*(Record your **three digit** answer in the Numerical Response boxes below)*

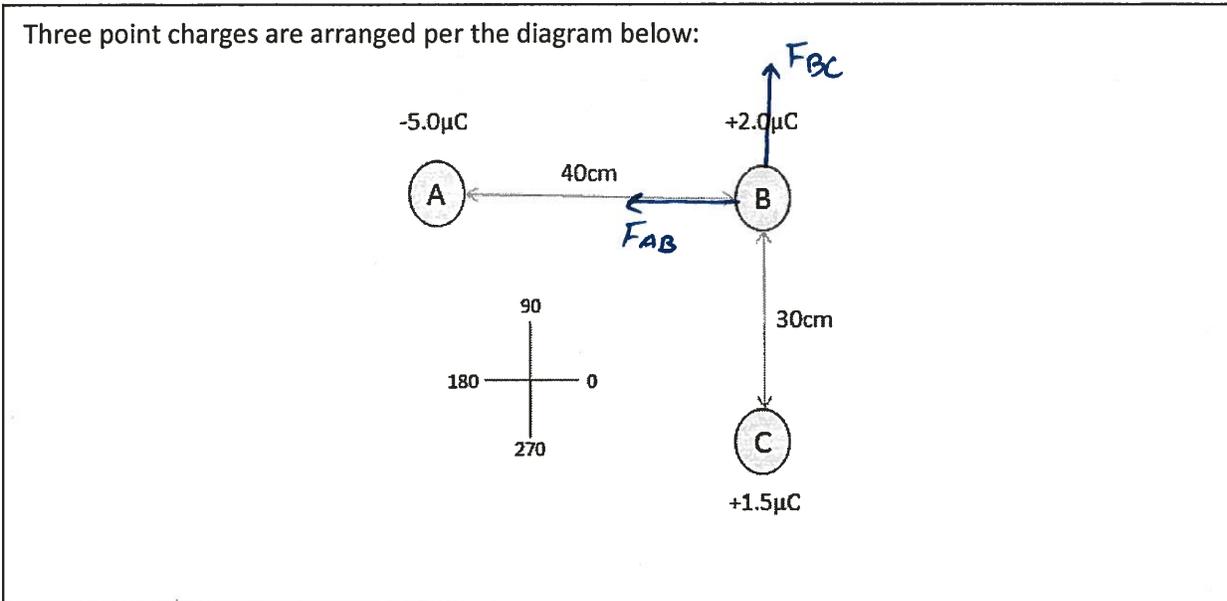| 7 | 1 | | |

7 - Conservation of Charge
1 - Accelerated Motion

Q9: *(Unit 1 question... these won't be on your Unit 2 summative assessments)* Which situation best describes the relative impulses experienced by each object at the moment of release?

a. ←—— (A)   (B) ——→

b. ←— (A)   (B) ———→

c.) ←—— (A)   (B) ——→

d. (A) ——→   ←— (B)

F∆t is impulse.
Same force for same
amount of time.

Use the following to answer Q10:

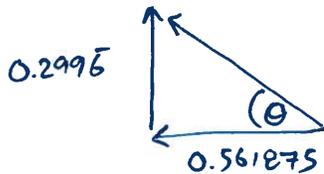Three point charges are arranged per the diagram below:

Q10: *Charge B* will experience a net force at _____ degrees.

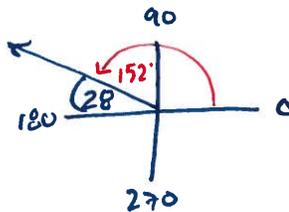*(Record your **three digit** answer in the Numerical Response boxes below)*

1	5	2	

$$F_{AB} = \frac{(8.99\times10^9)(5.0\times10^{-6})(2.0\times10^{-6})}{(0.4)^2} = 0.561875N$$

$$F_{BC} = \frac{(8.99\times10^9)(2.0\times10^{-6})(1.5\times10^{-6})}{(0.3)^2} = 0.2996\ N$$

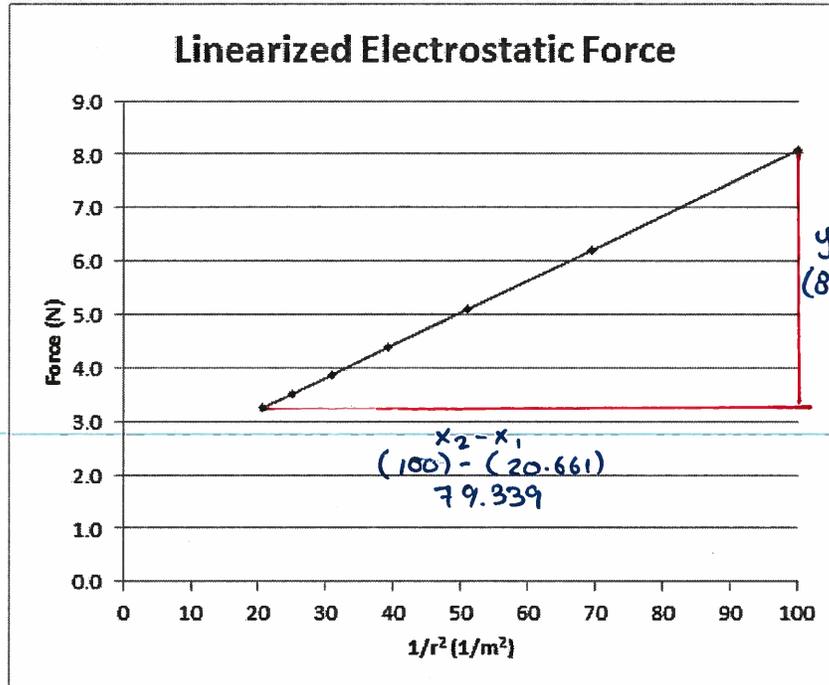$$\theta = \tan^{-1}\left(\frac{0.2996}{0.561875}\right)$$

$$\theta = 28.07°$$

L04 – Coulomb's Law Examined Graphically

Use the following information to answer Q11:

A charge of +4.50μC is placed at various distances from another charge of unknown magnitude. The electrostatic attraction between the two charges was graphed as a function of inverse distance squared. *So q_2 is negative.*

r	1/r^2	F
0.100	100.000	8.068
0.120	69.444	6.214
0.140	51.020	5.096
0.160	39.063	4.370
0.180	30.864	3.873
0.200	25.000	3.517
0.220	20.661	3.254

Linearized Electrostatic Force

$y_2 - y_1$
$(8.068) - (3.254)$
4.814

$x_2 - x_1$
$(100) - (20.661)$
79.339

Force (N) vs $1/r^2$ (1/m²)

Q11: What is the magnitude and nature of the unknown charge?

a. +1.50μC
b. -1.50μC *(circled)*
c. +1.98μC
d. -1.98μC

$Fe = (kq_1 q_2)\dfrac{1}{r^2} + 0$

$y = (m)x + b$

$Slope = \dfrac{rise}{run} = \dfrac{4.814}{79.339} = 6.0676338\,2447 \times 10^{-2}$

$Slope = kq_1 q_2$

$6.0676... \times 10^{-2} = (8.99 \times 10^9)(4.50 \times 10^{-6}) q_2$

$|q_2| = 1.4998 \times 10^{-6} C$

Attractive force towards positive charge means this charge is negative.

L05 – Electric Fields

Q12: What is the magnitude and direction of the electric field 12cm from a +8.0µC charge?

a. 5.99×10^5 N/C [toward source]
b. 5.99×10^5 N/C [away from source]
c. 4.99×10^6 N/C [toward source]
ⓓ 4.99×10^6 N/C [away from source]

$$|\vec{E}| = \frac{kq}{r^2} = \frac{(8.99\times10^9)(8.0\times10^{-6})}{(0.12)^2}$$

$$|\vec{E}| = 4.99\times10^6 \text{ N/c}$$

↑
← (+8.0 µC) →
↓

Field lines go **out of** positive charge.

Use the following information to answer Q13-Q14:

Two charges are oriented per the diagram below.

P | $\vec{E_A}$ ↑
$\vec{E_B}$
20cm → B –1.5µC
15cm
A +1.5µC

Directions

2
3 →
← 4
1
5 ↑ | ↓ 6
7 /
/ 8
×9
•0

Q13: Match the directions as numbered above with the descriptions given below.

Number:	5	3	8
Description:	Direction of electric field due to *Charge A*	Direction of electric field due to *Charge B*	Direction of net electric field at Point P

*(Record your **three digit** answer in the Numerical Response boxes below)*
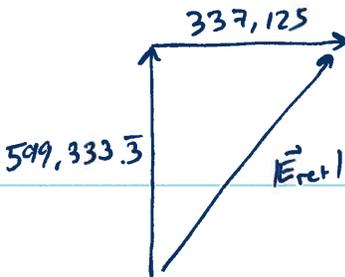
5	3	8	

Q14: The magnitude of the net electric field at *Point P* is **a.bc** x 10^d N/C, where **a, b, c,** and **d** are ___, ___, ___, and ___.

*(Record your **four digit** answer in the Numerical Response boxes below)*

6	8	8	5

$$|\vec{E_A}| = \frac{(8.99 \times 10^9)(1.5 \times 10^{-6})}{(0.15)^2} = 599,333.\overline{3} \text{ N/c}$$

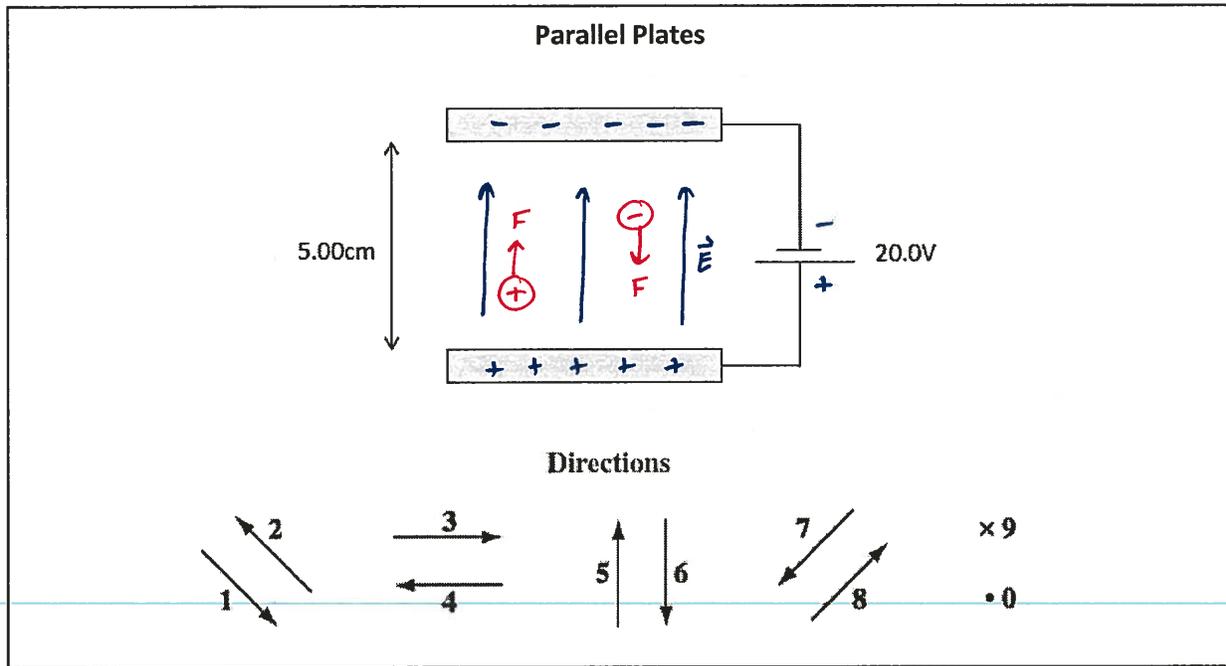$$|\vec{E_B}| = \frac{(8.99 \times 10^9)(1.5 \times 10^{-6})}{(0.20)^2} = 337,125 \text{ N/c}$$

337,125

599,333.$\overline{3}$ $\vec{E_{ret}}$

$$a^2 + b^2 = c^2$$

$$|\vec{E_{ret}}| = 687,643.592327 \text{ N/c}$$

$$\simeq 6.88 \times 10^5 \text{ N/c}$$

L07 – Parallel Plates

Use the following information to answer Q15-Q16:

Parallel Plates

Directions

Q15: Match the directions as numbered above with the descriptions given below.

Number:	5	5	6
Description:	Direction of electric field lines between the plates	Direction of force acting on a proton between the plates	Direction of force acting on an electron between the plates

*(Record your **three digit** answer in the Numerical Response boxes below)*

5	5	6	

Q16: The magnitude of the electric field between the plates is $a.bc \times 10^d$ N/C, where a, b, c, and d are ___, ___, ___, and ___.

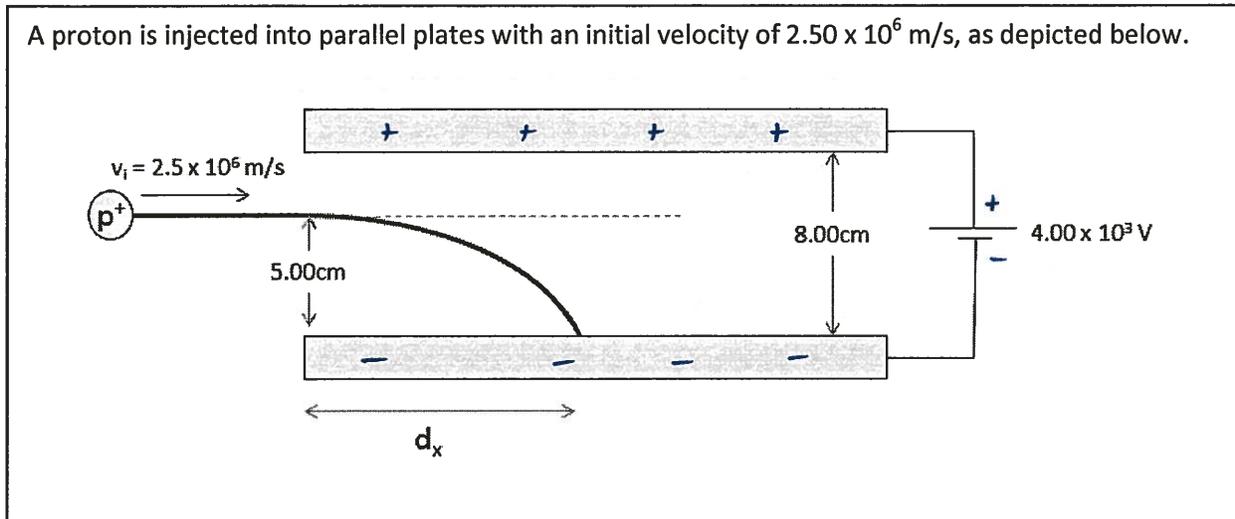*(Record your **four digit** answer in the Numerical Response boxes below)*

4	0	0	2

$$|\vec{E}| = \frac{\Delta V}{\Delta d} = \frac{20}{0.05} = 400\ \text{N/c}$$

$$\simeq 4.00 \times 10^2\ \text{N/c}$$

L08 – Parallel Plates and Projectile Motion

Use the following information to answer Q17:

A proton is injected into parallel plates with an initial velocity of 2.50×10^6 m/s, as depicted below.

$v_i = 2.5 \times 10^6$ m/s

8.00cm

4.00×10^3 V

5.00cm

d_x

Q17: The proton travels a horizontal distance of **a.bc** $\times 10^{-d}$ m before colliding with the lower plate, where **a, b, c,** and **d** are ____, ____, ____, and ____.

*(Record your **four digit** answer in the Numerical Response boxes below)*

3	6	1	1

① $|\vec{E}| = \frac{\Delta V}{\Delta d} = \frac{4.00 \times 10^3}{0.08} = 50,000$ N/C

② $\vec{F} = q\vec{E} = (1.60 \times 10^{-19})(50,000) = 8.00 \times 10^{-15}$ N

③ $a = \frac{F_{net}}{m} = \frac{8.00 \times 10^{-15}}{1.67 \times 10^{-27}} = 4.790419161 68 \times 10^{12}$ m/s²

x-comp

$v_x = 2.5 \times 10^6$ m/s
$d_x = ?$
$t = ?$

$v = \frac{d}{t}$

$d = (2.5 \times 10^6)(1.4448... \times 10^{-7})$
$d = 0.3612045 8192$ m
$\approx 3.61 \times 10^{-1}$ m

y-comp

$v_i = 0$ m/s
$a = 4.790419161 68 \times 10^{12}$ m/s²
$d = 0.05$ m
$t = ?$

$d = v_i t + \frac{1}{2} a t^2$
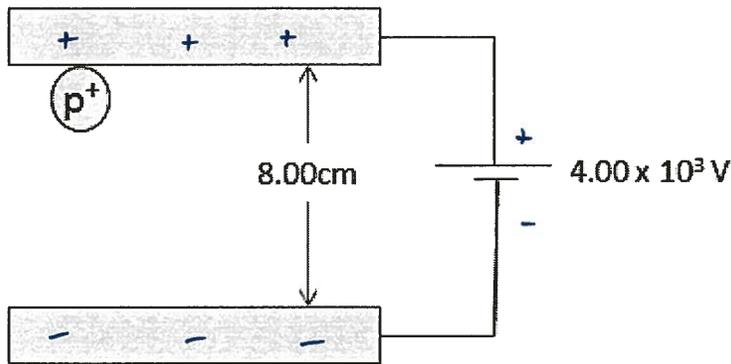$0.05 = (0)t + \frac{1}{2}(4.79... \times 10^{12})t^2$
$t^2 = 2.0875 \times 10^{-14}$
$t = 1.4448 18 32768 \times 10^{-7}$ s

L09 – Parallel Plates and Conservation of Energy

Use the following information to answer Q18-Q19:

A proton is placed on the positive plate of a set of parallel plates. When released, it accelerates downward and collides with the lower plate.

8.00cm 4.00 x 10³ V

Q18: The proton has a speed of *a.bc* x 10*ᵈ* m/s when it collides with the lower plate, where *a, b, c,* and *d* are ___, ___, ___, and ___.

*(Record your **four digit** answer in the Numerical Response boxes below)*

8	7	5	5

$$E_p \rightarrow E_k$$
$$q\Delta V \rightarrow \tfrac{1}{2}mv^2$$
$$(1.60\times10^{-19})(4.00\times10^3) = \tfrac{1}{2}(1.67\times10^{-27})v^2$$
$$v = 8.75\times10^5 \, m/s$$

Q19: The distance between the plates is doubled, while keeping the accelerating voltage the same. The new speed of the proton when colliding with the lower plate is *a.bc* x 10*ᵈ* m/s, where *a, b, c,* and *d* are ___, ___, ___, and ___.

*(Record your **four digit** answer in the Numerical Response boxes below)*

8	7	5	5

EASY

$$E_p \rightarrow E_k$$
$$q\Delta V = \tfrac{1}{2}mv^2$$
$$(1.60\times10^{-19})(4.00\times10^3) = \tfrac{1}{2}(1.67\times10^{-27})v^2$$
$$v = 8.75\times10^5 \, m/s$$

Electric field became weaker, force became weaker, and acceleration smaller...
BUT it had more distance over which to accelerate.

HARD

Q18 Confirm   vs

$$|\vec{E}| = \frac{\Delta V}{\Delta d} = 50,000 \, N/c$$
$$\vec{F} = q\vec{E} = 8.0\times10^{-15} \, N$$
$$a = \frac{F_{net}}{m} = 4.79...\times10^{12} \, m/s^2$$
$$V_f^2 = V_i^2 + 2ad$$
$$V_f^2 = (0)^2 + 2(4.79...\times10^{12})(0.08)$$
$$V_f^2 = 7.66\times10^{11}$$
$$V_f = 8.75\times10^5 \, m/s$$

Q19 Confirm

$$|\vec{E}| = \frac{\Delta V}{\Delta d} = 25,000 \, N/c$$
$$\vec{F} = q\vec{E} = 4.0\times10^{-15} \, N$$
$$a = \frac{F_{net}}{m} = 2.39...\times10^{12} \, m/s^2$$
$$V_f^2 = V_i^2 + 2ad$$
$$V_f^2 = (0)^2 + 2(2.39...\times10^{12})(0.16)$$
$$V_f^2 = 7.66\times10^{11}$$
$$V_f = 8.75\times10^5 \, m/s$$