Activity 3.4 – Physics 30 – Mr. Immel
Pre-Test Assignment
Electric Fields, Parallel Plates, Charged Drops

Due Date: Key

Read all the parts of your assignment carefully and record your answers in the appropriate place.

1. A charge of -4.27×10^{-8} C experiences an electrostatic force of repulsion of 7.91×10^{-4} N, north.

a. Calculate the magnitude of the electric field at the point in space occupied by the charge.

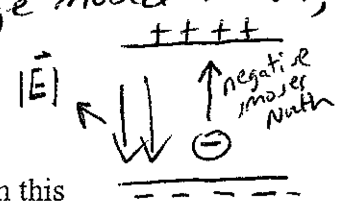
test charge

$$|E| = \frac{F_{el}}{q} = \frac{7.91\times10^{-4}\,N}{4.27\times10^{-8}\,C}$$

$$= 1.85\times10^{4}\,\frac{N}{C}$$

b. Determine the direction of the electric field. Explain your answer.

The direction of the $|\vec{E}|$ is defined as the direction a + test charge would be forced. Since the negative charge moved North, the direction of the field must be South.



2. A lightning bolt can deliver up to 20 C of charge to Earth.

a. Calculate the number of electrons transferred from the cloud to the ground in this discharge.

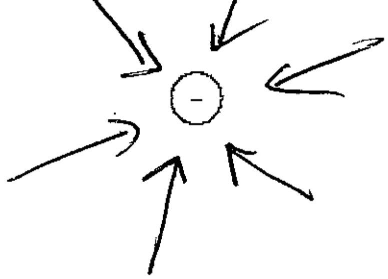
$$20\,C \times \frac{1\,e^-}{1.60\times10^{-19}\,C} = 1.3\times10^{20}\,e^-$$

or

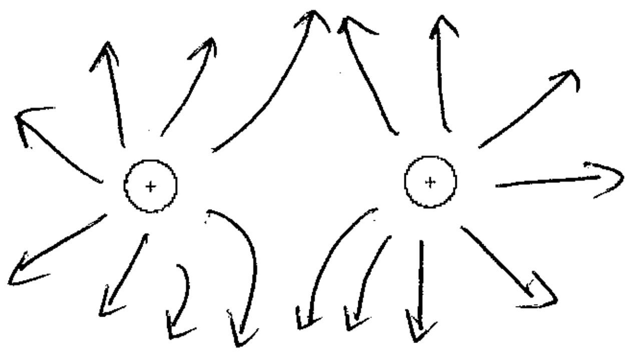
$$\frac{20\,C}{?\,e^-} = \frac{1.60\times10^{-19}\,C}{1\,e^-} = 1.3\times10^{20}\,e^-$$

3. Sketch the pattern of electric field lines for each of the following situations.

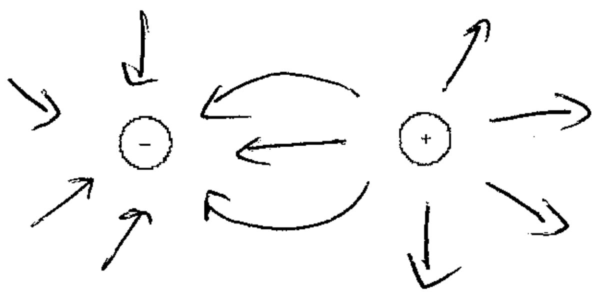
a.



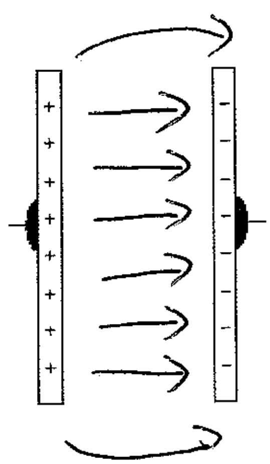
b.



c.



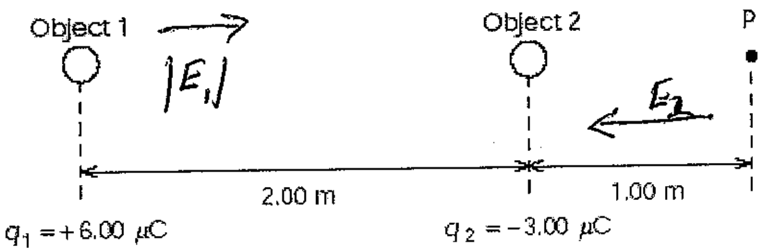
d.



4. The following diagram shows two charged objects, 1 and 2, and their positions relative to point **P**.

step 1: draw direction of $|\vec{E}|$ vectors relative to P...

how would a + charge at P move?



Calculate the magnitude and direction of the resultant electric field at point P.

step 2: calc. the strength of $|E_1|$ and $|E_2|$

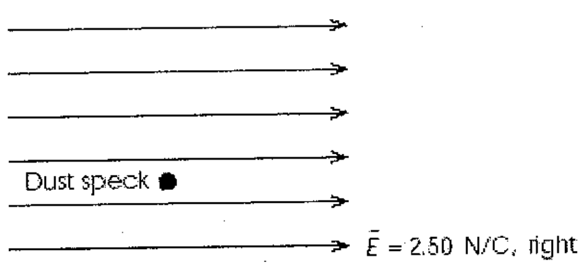
$$|\vec{E}_1| = \frac{kq}{r^2} = \frac{8.99\times10^9 \cdot 6\times10^{-6}}{(3.0m)^2} = 5.993\times10^3\ N/C$$

$$|E_2| = \frac{kq}{r^2} = \frac{(8.99\times10^9)(3\times10^{-6})}{(1.00)^2} = 2.697\times10^4\ N/C$$

step 3: Find $|\vec{E}|_{resultant} = 2.697\times10^4\ N/C - 5.993\times10^3\ N/C = 2.10\times10^4\ N/C$ [W]

5. The following diagram shows a positively charged dust speck within a uniform electric field of 2.50 N/C. The dust speck has a charge of +13.0 μC and a mass of 5.25 mg.

→ $5.25\times10^{-3}\ g$ or $5.25\times10^{-6}\ kg$



Ignore the effects of gravity and air resistance as you answer the parts of this question.

a. Calculate the magnitude and direction of the acceleration of the dust speck.

step 1: find F_{el} on dust speck (test charge)

$$|\vec{E}| = \frac{F_{el}}{q} \qquad 2.50\ N/C = \frac{F_{el}}{13.0\times10^{-6}\ C} \qquad F_{el} = 3.25\times10^{-5}\ N$$

step 2: find accel using Newton's 2nd law

$$\vec{F} = ma$$

$$3.25\times10^{-5} = 5.25\times10^{-6}\ kg \cdot a \qquad a = 6.19\ m/s^2\ (right)$$

b. Calculate the velocity of the dust speck after 2.00 s, assuming that it starts from rest.

Use Kinematics (Phys 20)

$a = 6.19\ m/s^2$
$v_i = 0$
$v_f = ?$
$t = 2.00\ s$

$a = \frac{v_f - v_i}{t}$

$6.19\ m/s^2 = \frac{v_f - 0}{2.00\ s}$

$v_f = 12.1\ m/s$ (right)

c. Calculate how long it would take this dust speck to travel 1.00 m in the direction of the electric field. Assume that it starts from rest.

$a = 6.19\ m/s^2$
$d = 1.00\ m$
$v_i = \phi$
$t = ?$

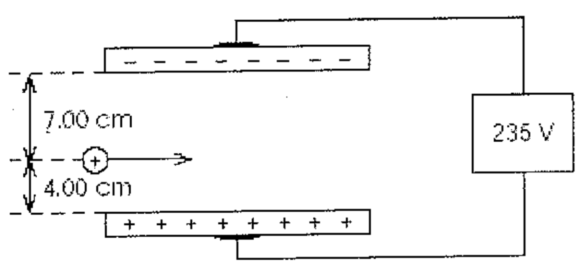
$d = v_i t + \frac{1}{2}at^2$

$1.00\ m = \frac{1}{2}(6.19\ m/s^2)t^2$

$0.568\ s = t$

6. A positively charged particle enters an evacuated region between two parallel plates with an initial horizontal velocity of 29.6 m/s, as shown in the following diagram. The particle has a mass of 35.6 mg and a charge of +8.40 nC.

→ no air!



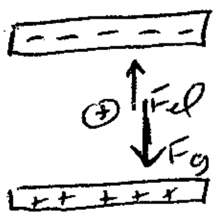
a. Will either the force of gravity or the force of air resistance play a role in the motion of this particle? Support your answer.

- gravity force - may be significant because the mass is large enough for gravity to be of the same order as the F_{el}

- no air, so no air resistance.

$F_g = mg$
$= (35.6 \times 10^{-6}\ kg)(9.81) = 3.49 \times 10^{-4}\ N$ stronger
will hit bottom plate

b. Do the necessary force calculations to determine which plate the particle will strike. Begin your solution with a labelled diagram.



Calculate both F_{el} and F_g to see which is stronger

$|E| = \frac{F_{el}}{q}$ or $\frac{V}{d} = \frac{F_{el}}{q}$, $\frac{239\ V}{.11\ m} = \frac{F_{el}}{8.40 \times 10^{-9}}$, $F_{el} = 1.79 \times 10^{-5}\ N$

c. Describe the motion of the particle in the horizontal and vertical directions. Support your answer by referring to Newton's laws.

$F_{el} = 1.79 \times 10^{-5}\ N$
F_g 3.49×10^{-4}

horizontal - no net force acting ... UNIFORM MOTION.

vertical since there is a F_{net} down, the particle will accelerate in this direction.

d. Determine the time that the particle will travel before it strikes one of the plates.

(vertical v is initially 0)

step 1: Find F_{net}

$F_{net} = F_g - F_{el}$
$= 3.49 \times 10^{-4}\ N - 1.79 \times 10^{-5}\ N$
$3.3313.. \times 10^{-4}\ N$ (down)

step 2: Find a

$F_{net} = ma$
$\frac{3.31... \times 10^{-4}\ N}{35.6 \times 10^{-6}\ kg} = a$
$9.31\ m/s^2$ (down) $= a$

step 3: Find time

$d = v_i t + \frac{1}{2}at^2$
$0.04 = \frac{1}{2} 9.31\ t^2$
$9.27 \times 10^{-2}\ s = t$

7. A student conducted a Millikan oil drop experiment. The student recorded the weight of each oil drop and then measured the necessary field intensity to hold each drop motionless between two horizontal plates. The student's data is shown in the following chart.

Weight ($\times 10^{-14}$ N)	Electric Field Intensity ($\times 10^{5}$ N/C)
1.6	1.0
2.7	1.6
3.8	2.2
5.7	3.6
6.3	3.8

a. Draw a graph of the data with the manipulated variable on the x-axis.

X values - List 1
y " - List 2

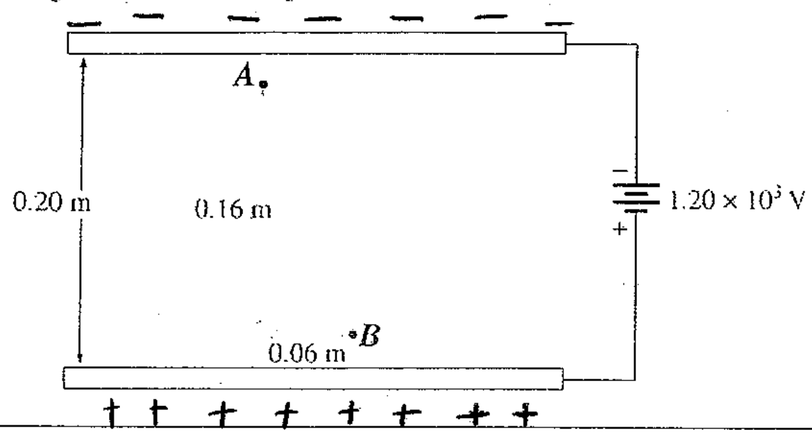
Try to find slope using linear regression on your calculator!

b. Use the slope of the graph to determine the best estimate of the elementary charge. (1.61×10^{-19} C)

8.

Use the following information to answer the next question.

Two oppositely charged parallel plates are separated by 0.20 m and have an electric potential difference of 1.20×10^3 V across them. Locations A and B are in the region between the plates, as shown below.



Work is required in order to move the test charge (e-) from B → A

a) Calculate the work required to move an electron from location B to A.

i) $|E| = \frac{V}{d} = \frac{1200\text{V}}{0.20\text{m}} = 6.0 \times 10^3 \frac{\text{V}}{\text{m}}$

ii) $|\vec{E}| = \frac{F_{el}}{q}$

$6.0 \times 10^3 \frac{\text{V}}{\text{m}} = \frac{F_{el}}{1.60 \times 10^{-19}\text{C}}$

$F_{el} = 9.6 \times 10^{-16}$ N

iii) $W = F_{el} d$

$(\Delta E)\ W = F_{el}\, d$

$= 9.6 \times 10^{-16}\text{N} \cdot .16\text{m}$

$= 1.536 \times 10^{-16}$ J

$= 1.5 \times 10^{-16}$ J

b) Calculate the potential difference (voltage) between B and A.

$V = \frac{\Delta E}{q}$

$= \frac{1.536 \times 10^{-16}\text{J}}{1.60 \times 10^{-19}\text{C}}$

$= 960$ V

9.6×10^2 V

the work done = Δ energy of the electron,

This means a coulomb of e- at position A has 960 J more potential energy than at position B.

c) No work is done against $\vec{E}$ so no E_p is gained.

9. An unknown charge is placed onto a 0.050 mg particle The particle is placed between two horizontal plates set 8.0 mm apart with a potential difference of 5 000 V across the plates. If the particle is suspended between the plates, what is the charge on the particle? How many excess electrons are on the particle?

↑ F_{el}
↓ F_g

$F_{el} = F_g$

$q|E| = mg$

$q\left(\frac{5000}{8.0\times10^{-3}\,m}\right) = (0.050\times10^{-6}\,kg)\cdot 9.81$

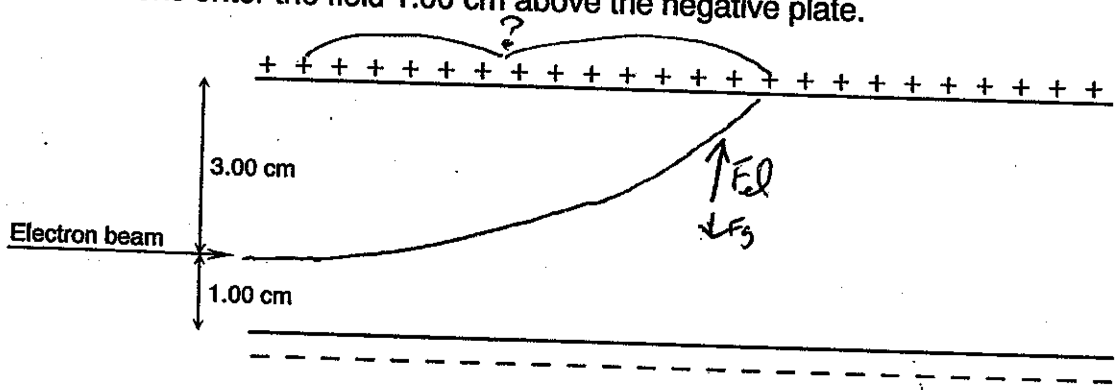
$q\ 6.25\times10^{5} = 4.905\times10^{-7}$

$q = 7.85\times10^{-13}\,C$

$\frac{7.85\times10^{-13}\,C}{1.60\times10^{-19}\,C/e^-}$

$4.91\times10^{6}\,e^-$

10. Two horizontal plates are separated by a distance of 4.00 cm. The electric potential between the plates is 120 V. A horizontal beam of electrons, with a speed of 6.50 x 10^6 m/s, is directed into the electric field between the plates. The electrons enter the field 1.00 cm above the negative plate.



Draw the resulting path of the electron beam. Determine the horizontal distance that the electrons travel before striking the positive plate. (The diagram is not drawn to scale)

i) find accel up

$F_{net} = F_{el} - F_g$

$ma = q|E| - mg$

$9.11\times10^{-31}\cdot a = 1.60\times10^{-19}\left(\frac{120}{0.04}\right) - 9.11\times10^{-31}\cdot 9.81$

$a = \frac{4.8\times10^{-16} - 8.93\times10^{-30}}{9.11\times10^{-31}}$

$a = 5.26..\times10^{14}\,m/s^2$

ii)

x (uniform)	y (accel)
$d = vt$	$d = 0.030$
$= 6.50\times10^{6}\cdot 1.068\times10^{-8}\,s$	$a = 5.26\times10^{14}$
$d = 0.0694\,m$	$v_i = 0$
or $6.94\,cm$	$t = ?$
	$d = \frac{1}{2}at^2$
	$0.030 = \frac{1}{2}\,5.26\times10^{14}\cdot t^2$
	$1.068\times10^{-8}\,s = t$

Name: ______________________ Class: _________________ Date: _________ ID: A

Practice Questions Show work for calculation questions

Multiple Choice

Identify the choice that best completes the statement or answers the question.

B 1. The fields that would be classified as vector fields are:

a. gravitational and temperature
(b) gravitational and electric
c. light and temperature
d. electric and energy

C 2. The electric field, experienced by an electron, at a point 30 cm from a light bulb, is about 5 N/C while the electric field experienced by an electron, in the first orbit of the hydrogen atom, can be in the order of 5 × 10^{11} N/C. The main reason why the electric field near the hydrogen atom is so much greater, is that:

a. the hydrogen nucleus possesses much more charge than the light bulb.
b. the hydrogen nucleus possesses much less charge than the light bulb.
(c) the distance to the hydrogen nucleus is much smaller.
d. the distance to the hydrogen nucleus is much greater.

$|\vec{E}| \propto \frac{1}{r^2}$ at a smaller distance, the $|\vec{E}|$ is stronger

Charges and Electric Fields

	Charge producing the electric field "q_1" ($\times 10^{-3}$ C)	Test charge placed in the electric field "q_2" ($\times 10^{-6}$ C)	Distance between the source charge and the test charge "r" ($\times 10^{-2}$ m)	Magnitude of the electric field at the test charge "$\lvert\vec{E}\rvert$" ($\times 10^{10}$ $\frac{N}{C}$)	Force experienced by the test charge "$\lvert\vec{F}_e\rvert$" ($\times 10^{5}$ N)
I.				7.99	0.799
II.	4.00			5.75	
III.		5.00			2.20
IV.	8.00	7.00	4.50		

B 3. Refer to the above table. The magnitude of the test charge in Row I is:

a. 1.00×10^{-1} C
(b) 1.00×10^{-6} C
c. 6.38 C
d. 6.38×10^{15} C

$|\vec{E}| = \frac{F_e}{q}$ $7.99 \times 10^{10} = \frac{.799 \times 10^5}{q}$

B 4. Refer to the above table. The distance between the source charge and the test charge in Row II is:

a. 6.25×10^{-4} m
(b) 2.50×10^{-2} m
c. 2.50×10^{3} m
d. 6.25×10^{9} m

$|E| = \frac{kq}{r^2}$ $5.75 \times 10^{10} = \frac{k\, 4 \times 10^{-3}}{r^2}$ $r = 0.025$ m

D 5. Refer to the above table. The magnitude of the electric field in Row III is:

a. $4.40 \times 10^{-1}\ \frac{N}{C}$
b. $1.10\ \frac{N}{C}$
c. $1.10 \times 10^{1}\ \frac{N}{C}$
(d) $4.40 \times 10^{10}\ \frac{N}{C}$

$|E| = \frac{F_e}{q} = \frac{2.2 \times 10^5 \text{ N}}{5 \times 10^{-6} \text{ C}}$

$= 4.4 \times 10^{10}\ \frac{N}{C}$

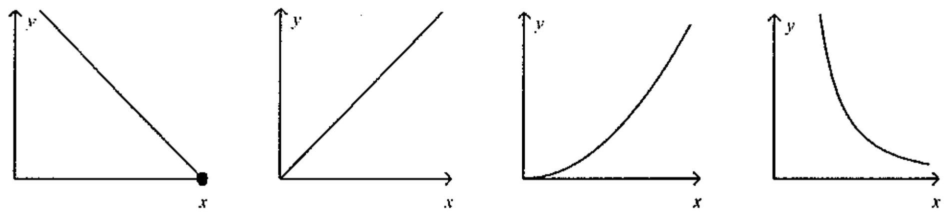
Name: ______________________ ID: A

6. Refer to the above table. The force experienced by the test charge in Row IV is:

a. 1.19×10^{4} N
b. 2.49×10^{5} N
c. 2.49×10^{10} N
d. 1.12×10^{11} N

The following graphs show the relationship between 2 variables, x and y.

I. **II.** **III.** **IV.**



7. The graph that shows the relationship between the magnitude of the electric field surrounding a point charge as a function of distance is:

a. I
b. II
c. III
d. IV

8. The graph that shows the relationship between the magnitude of the electric field as a function of the charge producing the field is:

a. I
b. II
c. III
d. IV

9. The direction of the electric field is defined as the direction of the force on a small test

a. mass
b. positive charge
c. negative charge
d. north magnetic pole

10. The magnitude of the electric field at a distance "r" from a point charge is "$|\vec{E}|$". When the distance from the point charge doubles, the magnitude of the electric field should be:

a. $2|\vec{E}|$
b. $\frac{1}{2}|\vec{E}|$
c. $\frac{1}{4}|\vec{E}|$
d. $4|\vec{E}|$

Name: ______________________ ID: A

	Comparison of Electric and Gravitational Fields
I.	Magnitude of the field varies as $\frac{1}{r^2}$.
II.	Direction of the field is always directed towards the centre of the object producing the field.
III.	Can exert attractive or repulsive forces on a test mass/charge.
IV.	Magnitude of the field depends on the quantity of the test mass/charge placed in the field.

gravity fields can't exert repulsive forces

C 11. Refer to the above table. The **correct** statement that applies only to electric fields and not gravitational fields is:

a. I
b. II
c. III
d. IV

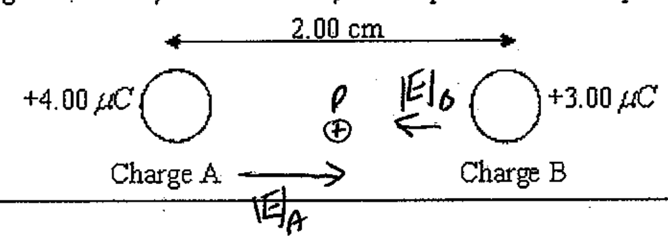
D 12. Refer to the above table. The **correct** statements that apply to both electric and gravitational fields are:

a. I and III
b. II and IV
c. II and III
d. I and IV

A 13. The units for electric field strength, in fundamental units, are:

a. $\frac{kg{\cdot}m}{Cs^2}$
b. $\frac{kg{\cdot}m}{As^2}$
c. $\frac{kg{\cdot}m{\cdot}s^2}{C}$
d. $\frac{kg{\cdot}m{\cdot}A}{s^2}$

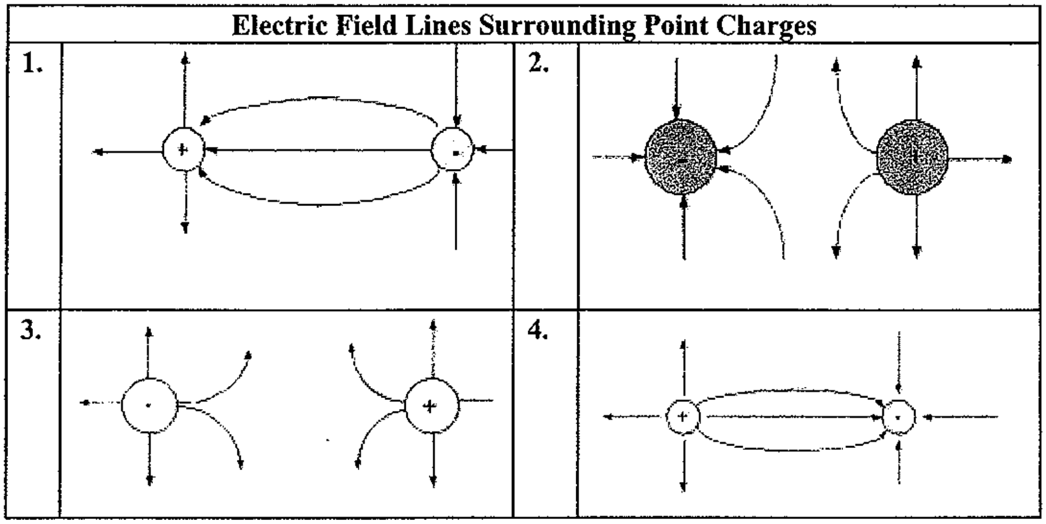
Charges of +4.00 μC and +3.00 μC are placed 2.00 cm apart as shown:



B 14. Refer to the above diagram. The direction of the net electric field, at a point P, midway between the two charges is:

a. towards the left
b. towards the right
c. towards the top of the page
d. towards the bottom of the page

D 15.

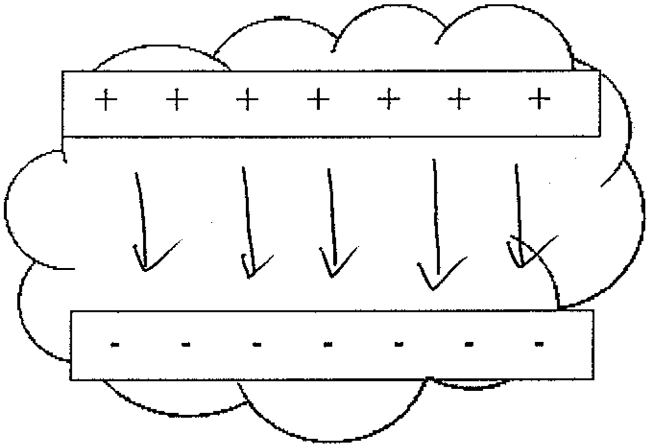


away from +

The **correct** electric field line diagram for a positive and a negative point charge is:

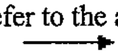
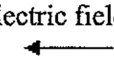
a. 1
b. 2
c. 3
d. 4

Thunderstorm



During a thunderstorm, a cloud created a potential difference between its upper positive and lower negative surfaces.

D 16. Refer to the above diagram. The direction of the electric field within the cloud is:

a. 
b. 
c. 
d. 

A 17. The volt is equivalent to:

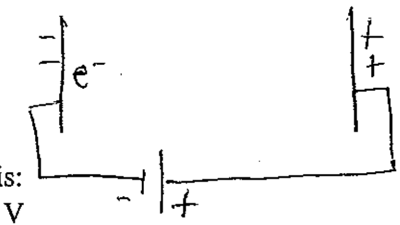
a. J/C
b. C/J
c. N/C
d. JC

$V = \frac{\Delta E}{q} = \frac{J}{C}$

Name: ______________________ ID: A

An electron is injected between two oppositely charged parallel plates connected to a DC voltage supply. The distance between the plates is 6.50 mm and the electron, initially at rest, accelerates towards the positive plate gaining 8.25×10^{-18} J of kinetic energy.

D 18. Based on the above information, the motion of the electron between the plates will be:
a. uniform motion towards the negative plate
b. uniform motion towards the positive plate
c. accelerated motion towards the negative plate
d. accelerated motion towards the positive plate



A 19. Based on the above information, the voltage between the plates is:
a. 51.6 V
b. 1.27×10^{-15} V
c. 5.26×10^{-23} V
d. 1.32×10^{-36} V

$V = \frac{\Delta E}{q} = \frac{8.25\times10^{-18}}{1.6\times10^{-19}} = 51.6\,V$

C 20. Based on the above information, the strength of the electric field between the plates is:
a. 335 V/m
b. 0.335 V/m
c. 7.93×10^{3} V/m
d. 7.93×10^{6} V/m

$|E| = \frac{V}{d} = \frac{51.56..}{6.5\times10^{-3}\,m} = 7.93\times10^{3}\,V/m$

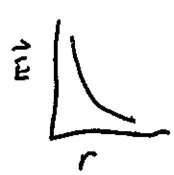
C 21. Based on the above information, the speed acquired by the electron as it reaches the positive plate is:
a. 7.03×10^{4} m/s
b. 3.01×10^{6} m/s
c. 4.26×10^{6} m/s
d. 1.81×10^{13} m/s

$\downarrow \Delta E_p = \uparrow E_K$

$8.25\times10^{-18} = \frac{1}{2} 9.11\times10^{-31} \cdot v^2$

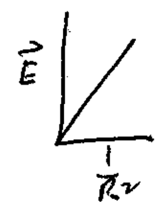
$4.26\times10^{6}\,m/s = v$

22. O



$\vec{E}$	R	$\frac{1}{R^2}$
1	1	1
$\frac{1}{4}$	2	$\frac{1}{4}$
$\frac{1}{9}$	3	$\frac{1}{9}$

$\vec{E} \propto \frac{1}{R^2}$



23. B $\vec{E} = \frac{F_e}{q}$ $20\,N/C = \frac{F_e}{3.20\times10^{-19}} = 6.4\times10^{-18}\,N$

24. 5.66 m 1st find q $\vec{E} = \frac{kq}{R^2}$

$4.00\times10^{-3} = \frac{kq}{(8)^2}$

$q = 2.85..\times10^{-11}\,C$

solve for R when $\vec{E}$ is $8\times10^{-3}\,N/C$

$8.00\times10^{-3} = \frac{k\,2.85..\times10^{-11}}{R^2}$

$R = 5.66\,m$