Physics 30: Chapter 3 Exam - Electrostatics

Name: _____   Date: _____   Mark: ____/33

Numeric Response. Place your answers to the numeric response questions, with units, in the blanks at the side of the page. (1 mark each)

1. Two small pith balls, each with a charge of +2.0 μC and +1.8 μC, repel each other with a force of 9.0 x 10^{-2} N. Determine the distance separating the two pith balls.

   60 cm

$$F = \frac{kq_1q_2}{r^2} \quad r = \sqrt{\frac{k(2\cdot10^{-6}C)(1.8\cdot10^{-6}C)}{(0.09N)}}$$

$$r = \sqrt{\frac{kq_1q_2}{F}} \quad r = 0.59966m$$

$$r = 60cm$$

2. Two charged objects repel each other with a force of 0.900 N. The charge on one is then tripled and the charge on the other is increased by a factor of 5/3. If the distance between them is then quadrupled, determine the magnitude of the resulting force.

   0.281 N

$$F_A = \frac{kq_1q_2}{r^2} \quad F_B = \frac{5}{16}F_A \quad F_B = 0.28125N$$

$$F_B = \frac{k\,3q_1\,5/3q_2}{(4r)^2} \quad F_B = \frac{5}{16}\,0.9N$$

3. Determine the maximum speed an alpha particle could reach if it moves from rest through a potential difference of 4.20 kV.

   6.36 x 10^5 m/s

$$E_{pi} = E_{kf}$$

$$Vq = \frac{1}{2}mv^2 \quad v = \sqrt{\frac{2*4.2\cdot10^3 V * 3.2\cdot10^{-19}C}{6.65\cdot10^{-27}kg}}$$

$$v = \sqrt{\frac{2Vq}{m}} \quad v = 635775.5 \, m/s$$

4. A 1.8 x 10^{-9} kg charged oil drop accelerates upwards in a vertical electric field of strength 500 N/C. When its acceleration is upwards at 3.0 m/s^2, the charge on the oil drop must be

   4.6 x 10^{-11} m/s^2

$$F_{net} = F_e - F_g \qquad Eq = m(a+g)$$

$$F_e = F_{net} + F_g \qquad q = \frac{m(a+g)}{|E|}$$

$$F_e = ma + mg$$

$$q = \frac{1.8\cdot10^{-9}kg\,(3m/s^2 + 9.81m/s^2)}{500N/C}$$

$$q = 4.61\cdot10^{-11}C$$

Written Response: Show all work. State your final answer, rounded to the appropriate number of significant digits, in a sentence.

1. A charged oil drop is sent in through the uniform electric field between two parallel plates as shown in the diagram below. The potential difference is adjusted so that the charged particle just contacts the upper right side of the positive plate. (Ignore the effects of the non-uniform electric field at the ends of the plates.) Determine the particle's horizontal velocity as it enters the field. (5 marks)

Mass of oil drop:	6.0×10^{-5} kg
Electric field between plates:	100 kV/m
Charge on particle:	2.4×10^{-8} C

0.020 m

+   +   +   +

0.010 m

−   −   −   −

$F_e = |E|q$

$F_e > F_g$

$F_g = mg$

X	Y
$V = \dfrac{d}{t}$	$d = v_i t + \frac{1}{2}at^2$
$= \dfrac{0.02m}{0.0257s}$	$d = \frac{1}{2}at^2$
$V = 0.777 m/s$	$t = \sqrt{\dfrac{2d}{a}}$
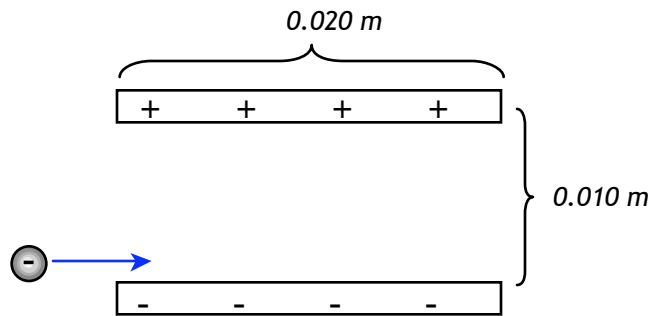
$F_{net} = F_e - F_g$

$\quad = 0.0024N - 0.0005886N$

$F_{net} = 0.00181 N$

$t = \sqrt{\dfrac{2(0.01m)}{30.19 m/s^2}}$

$t = 0.025739 s$

$|E| = \dfrac{F_e}{q}$

$F_e = |E|q$

$\quad = 100\frac{kV}{m} \times 2.4 \times 10^{-8} C$

$F_e = 0.0024 N$

$F_g = mg$

$\quad = 6 \cdot 10^{-5} kg \times 9.81 \frac{N}{kg}$

$F_g = 0.0005886 N$

$F_{net} = ma$

$a = \dfrac{F_{net}}{m}$

$\quad = \dfrac{0.0018 1 N}{6 \cdot 10^{-5} N}$

$a = 30.19 m/s^2$

The particle's horizontal velocity is 0.78 m/s.

Multiple Choice: Select the best answer. Mark it clearly on your Scantron. (1 mark each)

1. The total amount of charge contained within a closed system is constant. This statement is the Law of Conservation of
    a.   mass
    b.   energy
    c.   momentum
    d.   charge

2. Identify the list below that contains only vectors.
    a.   distance, force, acceleration, electric field
    b.   force, velocity, electric field, distance
    c.   electric field, force, velocity, displacement
    d.   force, velocity, distance, time

3. A positively charged object is brought near the left side of neutral metal sphere. Identify the diagram that best describes the electrical state of the sphere.
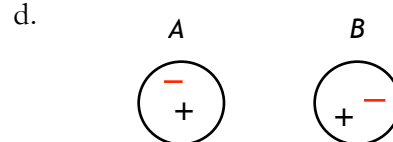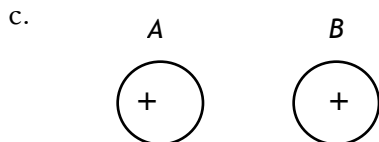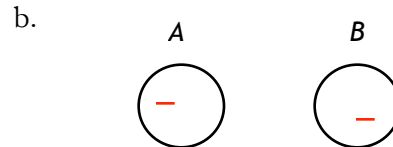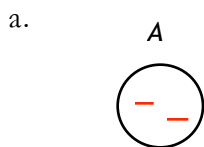
    a.   b.

    c.   d.
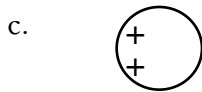
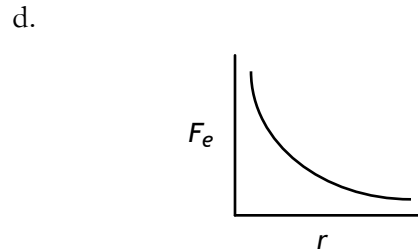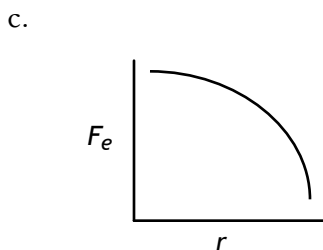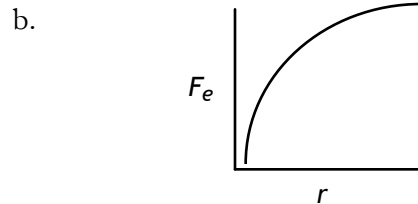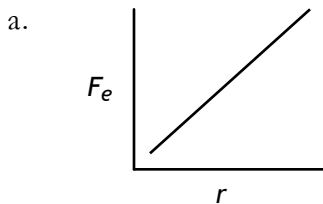*Use the information below to answer question 4.*

Two charged objects, A and B are brought into contact and then separated as shown in the diagram below.
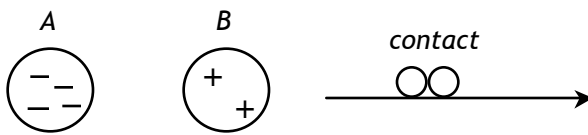
4. Identify the charge distribution on the two objects after separation.

    a.   b.

    c.   d.

5. Coulomb experimentally determine the value of Coulomb's constant (k) using
    a.   oil drop experiments
    b.   a torsion balance
    c.   an electroscope
    d.   parallel plates

6. A negatively charged **plastic** rod is brought near a small neutral piece of paper. A force of attraction results because the
    a.   paper loses protons
    b.   paper gains electrons
    c.   protons rearrange themselves
    d.   electrons rearrange themselves

7. Two very small spheres have charges of +3.0 μC and -6.0 μC are place 2.0 cm away from each other. The magnitude of the electric force on each sphere is
    a.   0.081 N
    b.   0.040 N
    c.   8.01 N
    d. 4.0×10^2 N

8. Two identical objects, one neutral and the other with a charge of +4.0 μC, are brought into contact and then separated to distance of 0.25 m. Calculate the magnitude of the electrostatic force between the two charged objects.
    a.   0.14 N
    b.   0.58 N
    c. 1.4×10^{11} N
    d. 5.8×10^{11} N

9. Identify the graph that best describes the relationship between electric force (F_e) and distance (r) between two charged objects.

    a.   b.
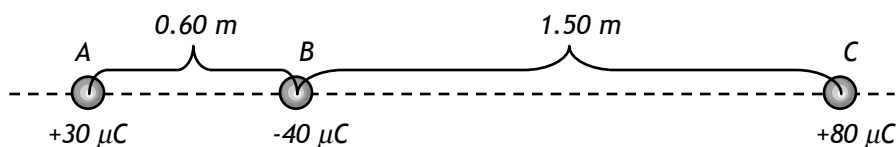
    c.   d.

Three point charges, A, B, and C, are arranged in a line as shown. Object A is positively charged.

A		B		C
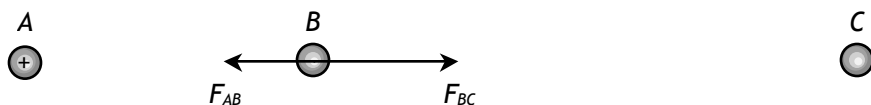
10. The charge on B and C must be

	B	**C**
a.	positive	negative
b.	positive	positive
c.	negative	positive
d.	negative	negative

11. Three point charges, A, B, and C, are arranged in a line as shown.

0.60 m   1.50 m

A   B   C

+30 μC   -40 μC   +80 μC

Determine the net electrostatic force acting on charge B.
   a.   17 N, left
   b.   17 N, right
   c.   43 N, left
   d.   43 N, right

12. Two positive point charges are placed as shown in the diagram. At point P the magnitude of the electric field due to charge A is 6.0 x 10^6 N/C. The magnitude of the electric field due to charge B at point P is 4.0 x 10^6 N/C. Determine the net electric field at point P.
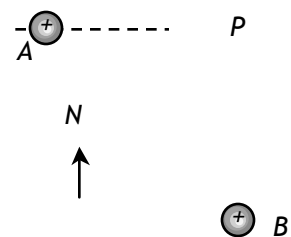
   a.   7.2 x 10^6 N/C, 56° N of E
   b.   7.2 x 10^6 N/C, 56° E of N
   c.   10 x 10^6 N/C, 56° N of E
   d.   10 x 10^6 N/C, 56° E of N

13. An electric field causes a small negatively charged particle to move to the east. The direction of the electric field is
   a.   north
   b.   south
   c.   east
   d.   West

14. An 8.20 x 10^{-15} kg oil drop is moving upwards at a constant speed of 1.60 m/s between two horizontal parallel plates. If the electric field strength between the plates is 2000 V/m, determine the magnitude of the drop's charge.
    a.   2.51 x 10^{-2} C
    b.   251 C
    c.   1.6 x 10^{-19} C
    d.   4.0 x 10^{-17} C

15. If a positively charged object is placed in an electric field that is directed downward, the direction of the electric force on the charge is
    a.   down
    b.   up
    c.   left
    d.   right

16. A proton that starts from rest is accelerated through a one megavolt potential difference. It reaches a maximum possible speed (ignoring relativistic effects) of
    a.   1.4 x 10^4 m/s
    b.   1.4 x 10^7 m/s
    c.   1.9 x 10^7 m/s
    d.   1.9 x 10^{14} m/s

17. A uniform electric field of 440 N/C exists between two large metal plates that are 40 cm apart. The potential difference between the plates is
    a.   1.8 x 10^4 V
    b.   1.1 x 10^3 V
    c.   1.8 x 10^2 V
    d.   1.1 x 10^2 V

18. Two positive charges, A and B, are placed close to each other. Charge A is 8.0 mC while charge B is 2.0 mC. The force on charge B due to charge A is
    a.   sixteen times as large as the force of A due to charge B.
    b.   four times as large as the force of A due to charge B.
    c.   one-quarter as large as the force of A due to charge B.
    d.   the same as the force of A due to charge B.

19. The stopping voltage for an electron travelling at 3.50 x 10^6 m/s is
    a.   34.9 V
    b.   9.96 x 10^{-6} V
   c.   28.7 mV
    d.   69.7 V

A computer program is used to simulate a charged oil drop experiment. Multiple trials are performed on the same oil drop where the potential difference is manipulated and the value of the upward acceleration responds. The data collected from the computer simulation is on the graph.

Where:
      q is the charge on the drop
      m is the mass of the drop
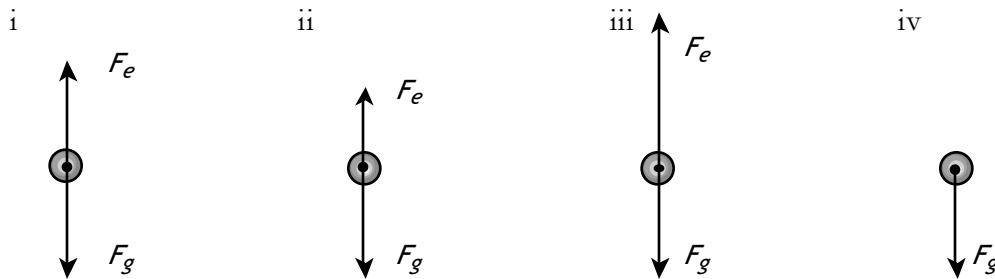   d is the distance separating the two parallel plates

Acceleration as a function of Potential Difference

Acceleration (m/s^2) vs. Potential Difference (V)
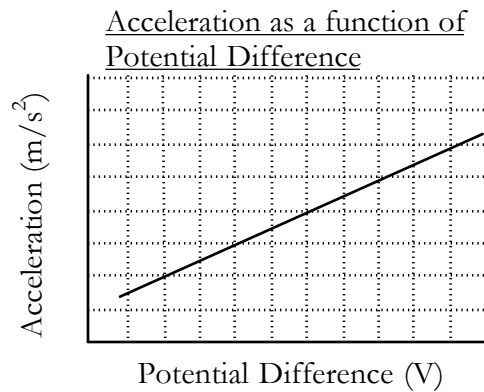
20. The slope of the line may be interpreted as
    a. $\dfrac{q}{md}$
    b. $\dfrac{md}{q}$
    c. $\dfrac{d}{mq}$
    d. $\dfrac{m}{qd}$

Four free-body diagrams for an oil drop are drawn below.

i F_e F_g ii F_e F_g iii F_e F_g iv F_g

21. Identify the free-body diagram that best describe an oil drop that is moving at constant velocity.
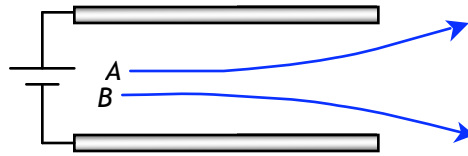   a.   i
    b.   ii
    c.   iii
    d.   iv

22. Identify the free-body diagram(s) that best describe an oil drop that is accelerating.
    a.   i
    b.   ii and iii
    c.   i, ii, iii, and iv
    d.   ii, iii, and iv

Two different subatomic particles (A and B) pass through a uniform field as shown in the diagram below.

23. Which best describes the charges on the particles as they travel through each field?

	Charge on A	Charge on B
a.	positive	positive
b.	positive	negative
c.	negative	positive
d.	negative	negative

An electron is accelerated from rest across a potential difference between two parallel plates separated by 8.0 cm as shown in the diagram below. Use the law of conservation of energy to complete the chart.
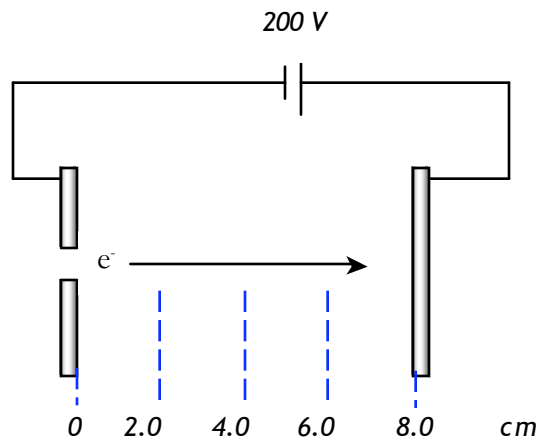
24. Select the energies possessed by the electron at the 6.0 cm mark.

	Kinetic energy (eV)	Electrical potential energy (eV)
a.	100	100
b.	50	150
c.	150	50
d.	175	25
e.	200	0

Stats

Class average on multiple choice: 66 %

Question	Answer	% Correct
1	D	50
2	C	90
3	B	59
4	B	50
5	B	59
6	D	55
7	D	88
8	B	88
9	D	96
10	C	96
11	A	63
12	B	84
13	D	71
14	D	90
15	A	67

Question	Answer	% Correct
16	B	75
17	C	71
18	D	71
19	A	84
20	A	38
21	A	96
22	D	80
23	C	71
24	C	38
25		
26		
27		