Last Name:________________First Name_________________NetID_______________
Discussion Section:________Discussion TA Name:_______________________________

Instructions—
Turn off your cell phone and put it away.
Keep your calculator on your own desk. Calculators may not be shared.
This is a closed book exam. You have ninety (90) minutes to complete it.

1. Use a #2 pencil; do **not** use a mechanical pencil or a pen. Fill in completely (until there is no white space visible) the circle for each intended input – both on the identification side of your answer sheet and on the side on which you mark your answers. If you decide to change an answer, erase vigorously; the scanner sometimes registers incompletely erased marks as intended answers; this can adversely affect your grade. Light marks or marks extending outside the circle may be read improperly by the scanner.

2. Print your last name in the **YOUR LAST NAME** boxes on your answer sheet and print the first letter of your first name in the **FIRST NAME INI** box. Mark (as described above) the corresponding circle below each of these letters.

3. Print **YOUR LAST NAME** in the designated spaces at the *left* side of the answer sheet, then mark the corresponding circle below each letter. Do the same for your **FIRST NAME INITIAL**.

4. You may find the version of **this Exam Booklet at the top of page 2**. Mark the **version** circle in the **TEST FORM** box in the bottom right of your answer sheet. **DO THIS NOW!**

5. Do not write in or mark the circles in any of the other boxes (STUDENT NUMBER, DATE, SECTION, SCORES, SPECIAL CODE).

6. Sign your name **(DO NOT PRINT)** on the **STUDENT SIGNATURE** line.

7. On the **SECTION** line, print your **DISCUSSION SECTION**. You need not fill in the COURSE or INSTRUCTOR lines.

Before starting work, check to make sure that your test booklet is complete. You should have 11 ***numbered pages*** *plus two Formula Sheets at the end.*

*Academic Integrity—***Giving assistance to or receiving assistance from another student or using unauthorized materials during a University Examination can be grounds for disciplinary action, up to and including expulsion.**

This Exam Booklet is Version A. Mark the **A** circle in the **TEST FORM** box in the bottom right of your answer sheet. **DO THIS NOW!**

Exam Grading Policy—

The exam is worth a total of 105 points, composed of two types of questions.

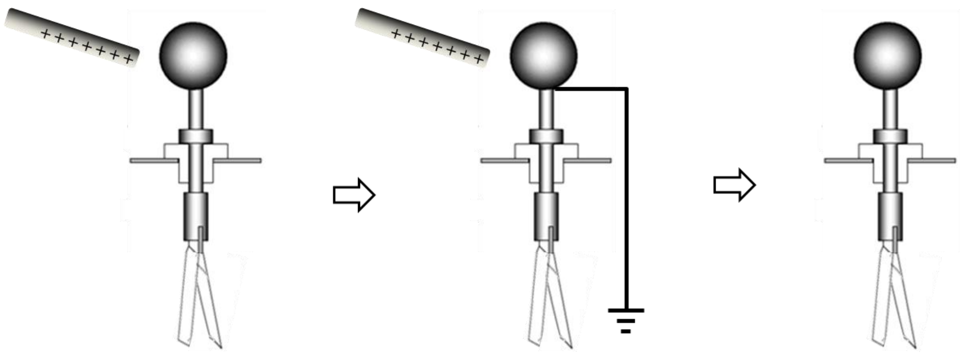
MC5: *multiple-choice-five-answer questions, each worth 6 points.*
Partial credit will be granted as follows.

(a) If you mark only one answer and it is the correct answer,
you earn **6** points.
(b) If you mark *two* answers, one of which is the correct answer,
you earn **3** points.
(c) If you mark *three* answers, one of which is the correct answer,
you earn **2** points.
(d) If you mark no answers, or more than *three*, you earn 0 points.

MC3: *multiple-choice-three-answer questions, each worth 3 points.*
No partial credit.

(a) If you mark only one answer and it is the correct answer,
you earn **3** points.
(b) If you mark a wrong answer or no answers, you earn **0** points.

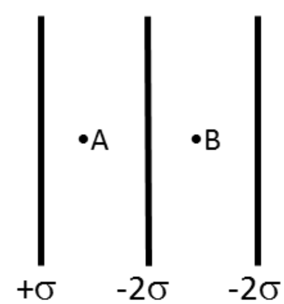
1. Consider an experiment on electrostatics, similar to those in your first lab session. A positively charged rod is brought near (but does not touch) an electroscope as shown below. Then, the electroscope is briefly grounded. Regarding the whole sequence of three steps, which statement is NOT true?



a. Negative charges will flow from the ground to the electroscope.
b. Positive charges will be induced on the electroscope when the rod is moved away.
c. The metal leaves at the bottom of the electroscope will repel each other when the rod is moved away.

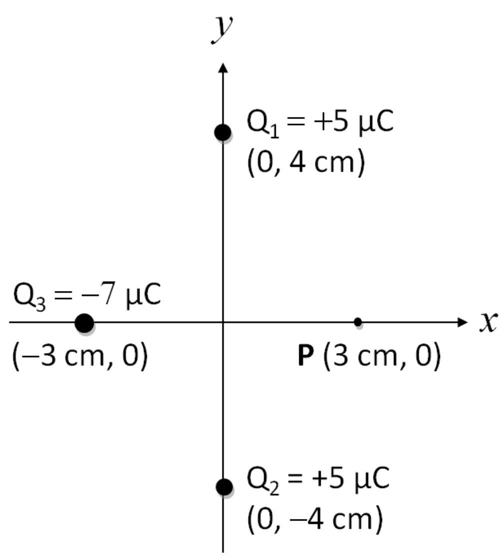
2. Consider three parallel infinite planes, with different surface charge densities as shown below. Find the ratio of the magnitude of the electric field at point A to the magnitude of the electric field at point B, E_A/E_B:

a. $E_A/E_B = 1$
b. $E_A/E_B = \infty$
c. $E_A/E_B = 2$
d. $E_A/E_B = 3/4$
e. $E_A/E_B = 5$



The next two questions pertain to the following situation:

Three point charges are placed on the *x*-*y* plane, as shown below.



3. What is the direction of the electric field at point **P** due to the two charges Q_1 and Q_2 only?

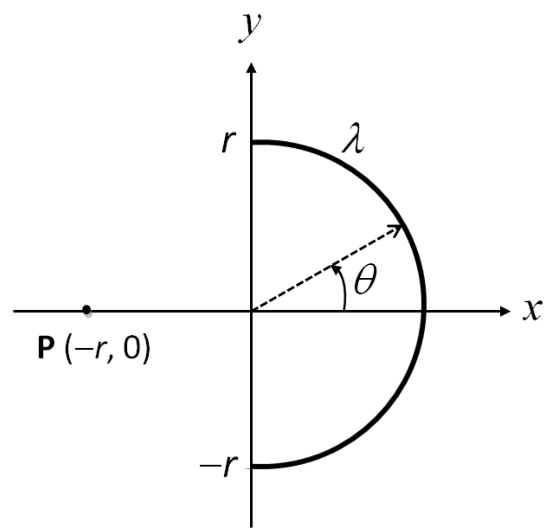
a. Negative *x*-axis
b. Positive *x*-axis
c. The electric field is zero at that point.

4. If a point charge of 1 Coulomb is placed at **P**, what is the *x*-component of the net electric force exerted on it by all the other three charges?

a. $F_x = -1.3 \times 10^7$ N
b. $F_x = +1.3 \times 10^7$ N
c. $F_x = +4.1 \times 10^6$ N
d. $F_x = -4.1 \times 10^6$ N
e. $F_x = +3.0 \times 10^4$ N

The next three questions pertain to the following situation:

A uniformly charged semi-circular line with linear charge density λ is placed in the x-y plane as shown at right. Its radius is r and its total charge $Q = +15\ \mu C$.



5. If $r = 5$ cm, what is λ?

a. $\lambda = 9.55 \times 10^{-5}$ C/m
b. $\lambda = 1.50 \times 10^{-4}$ C/m
c. $\lambda = 4.77 \times 10^{-5}$ C/m

6. What is the correct expression for the x-component of the total electric field *at the origin*, E_x, due to this charge?

a. $E_x = 0$

b. $E_x = -\int_{-\pi/2}^{\pi/2} d\theta \frac{k\lambda}{r} \cos\theta$

c. $E_x = -\int_{-\pi/2}^{\pi/2} d\theta \frac{k\lambda}{r} \cos\theta \sin\theta$

d. $E_x = -\int_{-\pi/2}^{\pi/2} d\theta \frac{k\lambda}{r} \sin\theta$

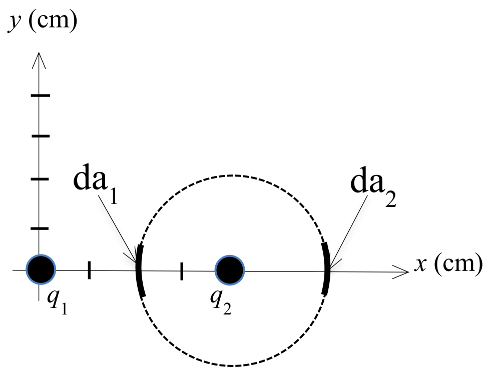
e. $E_x = -\int_{-\pi/2}^{\pi/2} d\theta \frac{k\lambda}{r^2} \cos\theta$

7. What kind of point charge should be placed at point **P**($-r$, 0) in order to make the net electric field at the origin vanish?

a. There is no such charge.
b. Negative charge
c. Positive charge

The next two questions pertain to the following situation:

Consider a charge $q_1 = +3\ \mu C$ placed at the origin and a charge $q_2 = -6\ \mu C$ placed a distance 4 cm away along the $+x$-axis. A spherical Gaussian surface of radius 2 cm is positioned around q_2, as shown below. Two small, equal sized patches—da_1 and da_2—are marked at different locations on the surface.



8. Compare the density of the electric field lines, n_1 and n_2, which pass through da_1 and da_2, respectively.

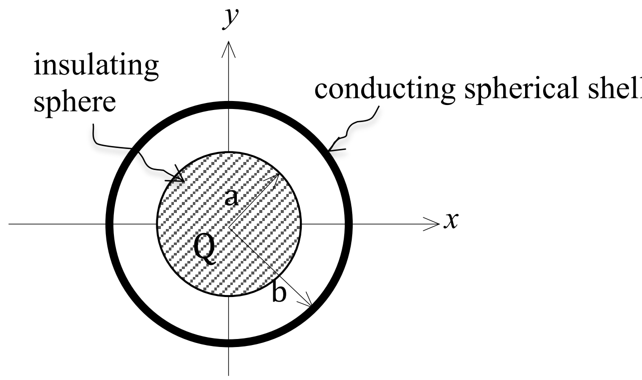
a. $n_1 = n_2$
b. $n_1 < n_2$
c. $n_1 > n_2$

9. What is the net flux that passes through the entire Gaussian surface?

a. -3.4×10^5 Nm^2/C
b. -6×10^{-6} C
c. -3×10^{-6} C
d. 6.8×10^5 Nm^2/C
e. -6.8×10^5 Nm^2/C

The next three questions pertain to the following situation:

Consider an <u>insulating sphere</u> of radius $a = 6$ cm, centered around the origin, that carries a total charge of $Q = +\,8\ \mu$C. (You may assume that the charge is distributed uniformly throughout the volume of the insulator). Concentric to the insulator is an uncharged <u>conducting spherical shell</u> of radius $b = 10$ cm, as shown at right.



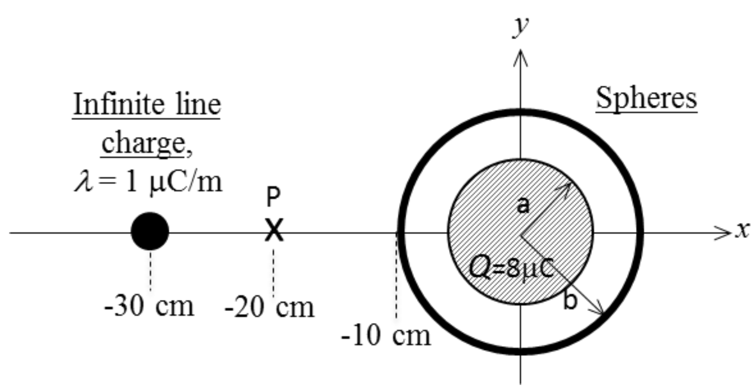
10. Find the magnitude of the electric field at a point located at $(x, y) = (4\text{ cm}, 0)$.

a. 4.50×10^7 N/C
b. 2.00×10^7 N/C
c. 9.47×10^6 N/C
d. 1.33×10^7 N/C
e. 1.98×10^6 N/C

11. Find the surface charge density on the <u>inner surface</u> of the spherical shell at $b = 10$ cm.

a. 0 C/m^2
b. -6.4×10^{-5} C/m^2
c. 8.0×10^{-6} C/m^2

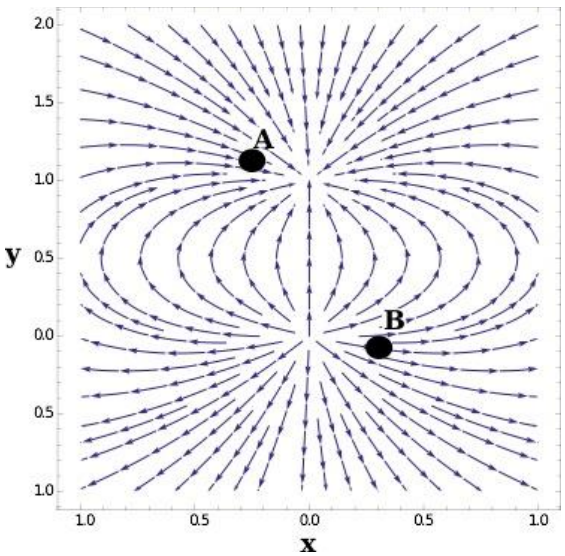
12. An infinite line charge having $\lambda = 1\ \mu$C/m is now added parallel to the z-axis and centered at $(x, y) = (-30\text{ cm}, 0)$, as shown at right. Find the electric field at the point P located at $(x, y) = (-20\text{ cm}, 0)$.



a. -7.0×10^6 N/C $\hat{x}$
b. -1.6×10^6 N/C $\hat{x}$
c. 2.0×10^6 N/C $\hat{x}$
d. 7.4×10^6 N/C $\hat{x}$
e. 1.8×10^5 N/C $\hat{x}$

The next three questions pertain to the following situation:

The electric field due to point charges is given below as a cross sectional view in the x-y plane:



13. What is the position of the point charges?

a. A positive charge at (0,0) and a negative charge at (0,1)
b. A positive charge at (0,1) and a negative charge at (0,0)
c. A positive charge at (1,0) and a negative charge at (0,0)

14. Which of these lines is an equipotential?

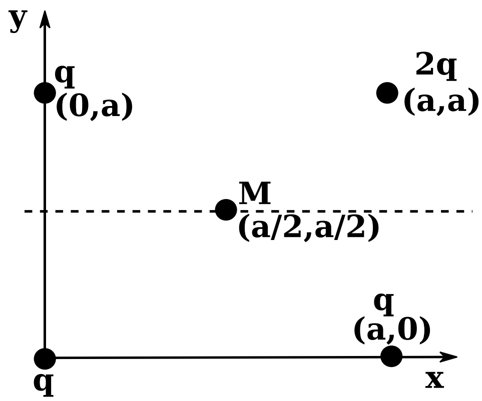
a. x=0.5
b. y=0
c. y=0.5
d. x=0
e. x=1

15. There are two points labeled A and B on the graph. What is the relationship between the potential at A and B? (You may take ∞ as your zero-potential reference).

a. $V_A > V_B$
b. $V_A = V_B$
c. $V_A < V_B$

The next three questions pertain to the following situation:

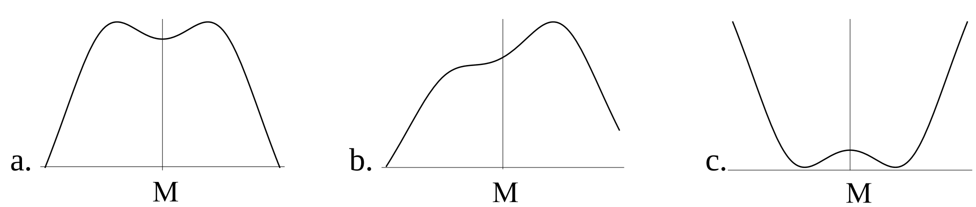
Four point charges with charge q, q, q, and $2q$ are arranged as shown in the diagram.



16. What is the work required to assemble this charge configuration? Assume the charges start at infinity.

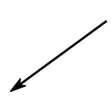
a. $\frac{q}{4\pi\epsilon_0 a}\left(2+\sqrt{2}\right)$
b. $\frac{q}{4\pi\epsilon_0 a}\left(3+\frac{1}{\sqrt{2}}\right)$
c. $\frac{q^2}{4\pi\epsilon_0 a}\left(6+\frac{3}{\sqrt{2}}\right)$
d. $\frac{q^2}{4\pi\epsilon_0 a}\left(\frac{4}{\sqrt{3}}\right)$
e. $\frac{q^2}{4\pi\epsilon_0 a}(5)$

17. Which sketch below is a better representation of the electric potential along the dotted line in the figure above? Note that point M is marked in the sketches.



18. If a positively charged particle is placed at M, what is the best representation of the direction of the force on that particle?

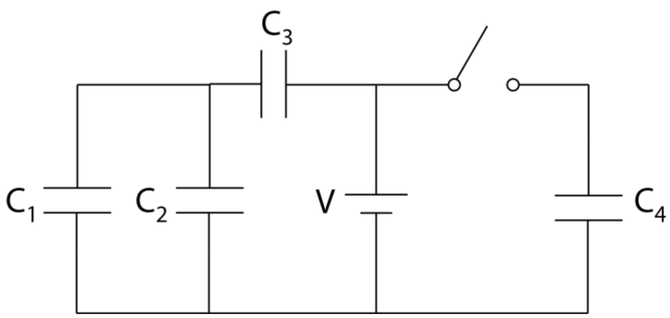
a. The net force is zero.

b. 

c.

The next four questions pertain to the following situation:

Four parallel plate capacitors are connected to a battery as shown in the circuit diagram. For the problems below, the switch has been closed for a long time, and the charge on capacitor C_1 is observed to be 5.83 μC. (Note 1 μC = 10^{-6} C.)



$C_1 = 6\ \mu F$

$C_2 = 8\ \mu F$

$C_3 = 12\ \mu F$

$C_4 = 10\ \mu F$

19. Capacitors C_3 and C_4 are connected

a. neither in series nor in parallel
b. in series
c. in parallel

20. What is C_{1234}, the equivalent capacitance of the combination of four capacitors?

a. $C_{1234} = 16.5\ \mu F$
b. $C_{1234} = 14.3\ \mu F$
c. $C_{1234} = 36.0\ \mu F$
d. $C_{1234} = 25.4\ \mu F$
e. $C_{1234} = 2.1\ \mu F$

21. What is V_3, the voltage across C_3?

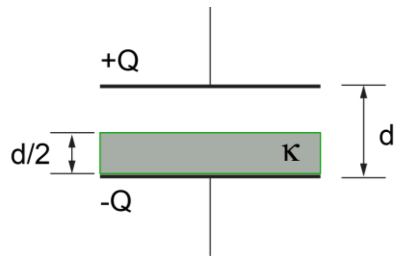
a. $V_3 = 0.97$ Volts
b. $V_3 = 0.49$ Volts
c. $V_3 = 1.13$ Volts
d. $V_3 = 0.71$ Volts
e. $V_3 = 0.83$ Volts

22. What is $V_{battery}$, the voltage across the battery?

a. $V_{battery} = 0.97$ Volts
b. $V_{battery} = 2.11$ Volts
c. $V_{battery} = 0.49$ Volts

The next two questions pertain to the following situation:

A parallel plate capacitor is constructed with a dielectric slab with $\kappa = 1.5$ inserted between the plates. The area of each plate is 5 cm^2, and the distance between the two plates is 1 mm. Assume the infinite plane approximation.



23. If we fix the charge on the capacitor to be $Q = 6\times10^{-11}$ C, what is the potential difference between the top and bottom plates? Note that in the region containing the dielectric medium, the electric field is $E = E_0 / \kappa$, where E_0 is the electric field in vacuum.

a. $\Delta V = 13.6$ Volts
b. $\Delta V = 6.0$ Volts
c. $\Delta V = 11.3$ Volts
d. $\Delta V = 9.0$ Volts
e. $\Delta V = 5.6$ Volts

24. What is the capacitance of this configuration? (Note: 1 pF = 10^{-12} F)

a. C = 17.7 pF
b. C = 5.3 pF
c. C = 8.9 pF

Check to make sure you bubbled in all your answers.
Did you bubble in your name, exam version and network-ID?