NAME (print please)__________________________________________

Student ID #__________________________________________________

TA’s Name(Circle one!): Edwin Widjonarko, Craig Hogle, Mike Mullan, Mike Hermele, Naresh Sen

Starting time of your Tues recitation (write time in box: 9am, noon, 1pm, etc)  

Please do not open the exam until you are told to. Your exam should have 12 pages, numbered 1 thru 12. This exam consists of 18 multiple-choice questions worth 75 points total, and two multipart long-answer questions worth 25 points total. Fill in the bubble sheet with a #2 pencil.

PLEASE follow all directions carefully – if you don’t, we may not be able to identify your exam (which would be a disaster for you!) Place a check in each box on the left as you complete the instructions.

Circle your TA's name above.

Print and bubble in your name on the bubble sheet.

☐ Print and bubble in your student Identification Number.

☐ Print and bubble in your Exam version, 0001 or 0002, in the upper left of your bubble sheet in the area marked 1234.

☐ Erase mistakes as thoroughly as possible. Ask for a fresh bubble sheet if you fear you cannot thoroughly erase mistakes.

☐ After you begin, be sure to neatly print your name and ID on the long answer question pages.

At the end of the exam, check that you have filled in the first 18 questions on the bubble sheet, with only one bubble filled in for each question.

☐ I have read and followed the instructions above.

Signature_____________________________________________________

Note: 1eV (electron-Volt) = 1.6×10^{-19} J. Charge of the electron e = 1.6×10^{-19} C.
NOTE: In ALL questions, please assume the electrical potential is defined to be zero at infinity, unless otherwise explicitly stated.

1. A small surface is completely enclosed by a larger surface. The volume inside the first surface is $V_1$. The volume between the first and the second surface is $V_2$. The total outward flux through the inner surface is positive, but the total outward flux through the outer surface is negative.
   What is the sign of the total charge contained within the volume $V_2$?

   A) Positive  
   B) Zero  
   C) Negative  
   D) Impossible to tell

2. Two uniformly charged rods are each bent into a quarter circle of radius $R$. The left rod is positive, with linear charge density $3 \lambda$. The right rod is negative, with linear charge density $-\lambda$.
   What is the electrical potential at the point $A$, located at the center as shown??

   A) $V = \pi \lambda R$  
   B) $V = \pi \lambda R / R$  
   C) $V = 2 \pi \lambda R$  
   D) $V = 2 \pi \lambda k/R$  
   E) $V = \lambda k/R$
A uniformly charged rod with linear charge density $\lambda$ is positioned vertically as shown, so that the distance between its lower end and the origin is $L$. Its height is $H$. What is the potential at a point located on the y-axis, at a distance $D$ from the origin?

A) 

$$V = k \int_0^H dy \frac{\lambda}{\sqrt{y^2 + H^2}}$$

B) 

$$V = k \int_0^H dy \frac{\lambda}{y^2 + H^2}$$

C) 

$$V = k \int_0^H dy \frac{\lambda}{(y - D)^2 + H^2}$$

D) 

$$V = k \int_0^H dy \frac{\lambda}{\sqrt{(y - D)^2 + H^2}}$$

3. E) 

$$V = k \int_0^H dy \frac{\lambda L}{((y - D)^2 + H^2)^{\frac{3}{2}}}$$
4. A charged rod with the positive charge Q uniformly distributed along its length is positioned as shown. Is the potential $V_A$ at a point A

A) $V_A > kQ/r$  B) $V_A = kQ/r$  C) $kQ/r > V_A > kQ/L$
D) $V_A = kQ/L$  E) $V_A < kQ/L$

*The next three questions refer to the figure below.*

5. The figure on the right shows the equipotential lines of the electric field. A proton at rest is placed at a point A. Which direction will it start moving?

A) up  B) down  C) right  D) left  E) will remain at rest

6. At which point is the electric field the weakest?

A) At the point A  B) At the point B  C) At the point C  D) It is equally strong at points B and C  E) It is equally strong at all three points

7. How much external work does it take to move the proton, with constant velocity, from the point B to C?

A) 3 eV  B) 6 eV  C) -3 eV  D) -6 eV  E) $1.6 \times 10^{-19}$ eV
8. The circuit shown on the picture includes three identical capacitors, each having capacitance $C$. How does the charge $Q_1$ on the plates of the capacitor 1 compare with the charge $Q_2$ on the plates of the capacitor 2?

A) $Q_1 / Q_2 = 1$
B) $Q_1 / Q_2 = 1/2$
C) $Q_1 / Q_2 = 1/3$
D) $Q_1 / Q_2 = 3$
E) $Q_1 / Q_2 = 2$

9. What is the effective capacitance of this circuit?

A) C  B) 2C  C) 2C/3  D) 3C/2  E) 3C

10. A large parallel plate capacitor, whose plates’ area is $A$ and distance between the plates $d$, is charged so that the charges on its plates are $Q$ and $-Q$. Its plates are isolated. A metal slab of thickness $L$ is inserted between the plates, as shown. How would the electric field’s strength at the point A change if the slab were removed?

A) Increase  B) Decrease  C) Remain the same  D) Impossible to tell

11. How would the energy of the capacitor change if the slab were removed?

A) Increase  B) Decrease  C) Remain the same  D) Impossible to tell

12. An electron is injected between the plates of a large parallel plate capacitor, exactly in the middle, with the initial kinetic energy $KE_i$. The distances between the plates is $d$, the charges on the plates are $+Q$ and $-Q$. What is the final kinetic energy $KE_f$ of the electron as it hits one of the plates?
13. What is the potential at the center of the square shown on the figure? Four charges are located at the corners of this square, as shown.

A) \( V = 0 \)  
B) \( V = k \frac{Q}{\sqrt{2d}} \)  
C) \( V = -k \frac{Q}{\sqrt{2d}} \)  
D) \( V = -\sqrt{2}k \frac{Q}{d} \)  
E) \( V = -6k \frac{Q}{\sqrt{2d}} \)
14. A circuit consists of a battery and three resistors, as shown. The current through each of the resistors is $I$. What is the current through the battery?

![Circuit Diagram]

A) $I$
B) $3I$
C) $2I$
D) 0
E) $-I$

15. Two charges, $+Q$ and $+2Q$, are arranged in the way shown. What is the potential at the point $A$?

![Charge Diagram]

A) $3Q/r$
B) $3Q/(2r)$
C) $Q/r$
D) 0
E) $2Q/r$

16. The figure on the right shows field lines of the electric field. Which one of the figures below shows correctly the equipotential lines of this electric field?

![Equipotential Lines]

Ver 0001
17. A wire carries a current of 20A. How many electrons pass through this wire in 1 minute?

A) $7.5 \times 10^{21}$
B) $1.25 \times 10^{20}$
C) $2.0 \times 10^{10}$
D) 20
E) $1.6 \times 10^{-19}$
18. Two resistors, one is twice as long but only half as thick as the other (its diameter is half as big). What is the ratio of their resistances?

\[ \frac{R_2}{R_1} \]

A) \( \frac{R_2}{R_1} = 1 \)
B) \( \frac{R_2}{R_1} = 2 \)
C) \( \frac{R_2}{R_1} = 4 \)
D) \( \frac{R_2}{R_1} = 8 \)
E) \( \frac{R_2}{R_1} = \frac{1}{2} \)
Question 1.

A two dimensional charged plane with charge density $\lambda$ cuts exactly in the middle through an imaginary cubic Gaussian surface of edges of length $r$, so that it cuts the cube into two identical pieces.

(a) What is the electric field flux through the surface of the cube.

(b) Will the flux increase, decrease or remain the same if the surface is shifted to the right (so that it still cuts through the cube, but no longer exactly in the middle), while remaining parallel to its previous position? Explain your reasoning.

(c) Will the flux increase, decrease or remain the same if the surface is tilted to the side, in such a way that it still cuts through the cube through the same edges as before?
Two large conducting plates are placed parallel to each other a distance D apart. The upper plate is charged with charge +Q, while the lower one is charged with charge -Q. The plates are then connected to box X, as shown above on the left.

Subsequently two additional uncharged metal plates are attached to the original plates, as shown above on the right. The electric field between the plates is observed to decrease.

(a) Is it possible, in view of the information above, that the box X contains a battery, as shown below? Explain.

(b) Is it possible, in view of the information above, that the box X contains an open circuit, as shown below? Explain.

(c) Suppose the plates are brought closer together. In view of the information above, will the electric field between the plates (circle the right answer)
increase, decrease, or remain the same?

(d) Explain your answer in part (c).

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