1) Do not open this exam until instructed to do so.
2) This exam consists of 15 multiple choice questions. Clearly circle your answers.
3) For some questions, relevant information might be given in the included figure.
4) You have 50 minutes to complete this exam.
5) Do not interact with anyone except Dr. Rittenhouse during the exam.
6) Do not discuss this exam with any other students who have not taken the exam.
7) When you have completed the entire exam, write your final answers on the answer sheet provided. Be sure to write your name at the top of the answer sheet and hand it in. These will be the answers you are graded on. Take the rest of the exam packet with you for use in exam corrections.
1. Two point charges are located on the x-axis with the +2.0 \(\mu\)C charge at the origin. The total electric field at point P is closest to

A) \(7.5 \times 10^7 \hat{i} \text{ N/C}\)
B) \(1.5 \times 10^7 \hat{j} \text{ N/C}\)
C) \(-7.5 \times 10^7 \hat{i} \text{ N/C}\)
D) \(-1.5 \times 10^7 \hat{i} \text{ N/C}\)
E) \(1.5 \times 10^7 \hat{i} \text{ N/C}\)

2. The dashed circle represents the cross section of a spherical Gaussian surface. There are charges of +7.0 C and -2.0 C inside the Gaussian surface and +4.0 C and -5.0 C outside the surface as shown. The net (total) electric flux through the Gaussian surface is closest to

A) \(-4.5 \times 10^{11} \text{ Nm}^2/\text{C}\)
B) \(5.6 \times 10^{11} \text{ Nm}^2/\text{C}\)
C) \(4.5 \times 10^{11} \text{ Nm}^2/\text{C}\)
D) \(-5.6 \times 10^{11} \text{ Nm}^2/\text{C}\)
E) 0

3. A conducting spherical shell of radius \(r_o = 0.070 \text{ m}\) has a uniform surface charge density of \(\sigma = 2.0 \mu\text{C}/\text{m}^2\) on its outer surface. The magnitude of the electric field at points 0.050 m and 0.100 m (from center of shell), respectively are closest to

<table>
<thead>
<tr>
<th>Row</th>
<th>(E) at 0.050 m from center</th>
<th>(E) at 0.100 m from center</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0</td>
<td>(1.1 \times 10^5 \text{ N/C})</td>
</tr>
<tr>
<td>B</td>
<td>(1.8 \times 10^6 \text{ N/C})</td>
<td>0</td>
</tr>
<tr>
<td>C</td>
<td>0</td>
<td>(1.8 \times 10^6 \text{ N/C})</td>
</tr>
<tr>
<td>D</td>
<td>(1.1 \times 10^5 \text{ N/C})</td>
<td>0</td>
</tr>
<tr>
<td>E</td>
<td>0</td>
<td>0</td>
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</tbody>
</table>
4. In the diagram below, the dashed lines are equipotentials. In which region of space is the magnitude of the electric field the largest?

![Diagram with equipotentials labeled A to E and potentials 0V, 1V, 2V, 3V, 4V, 5V.]

5. A beam contains $8.0 \times 10^5$ doubly charged positive ions per cubic centimeter (+2e worth of charge per ion), all of which are moving in the same direction with a speed of $6.5 \times 10^5$ m/s. What is the magnitude of the current density of this beam?

A) $0.42 \times 10^{-7}$ A/m²  
B) $0.84 \times 10^{-7}$ A/m²  
C) $1.25 \times 10^{-7}$ A/m²  
D) $1.67 \times 10^{-7}$ A/m²  
E) $2.50 \times 10^{-7}$ A/m²

6. A resistor is made using a cylindrical piece of conducting material with a cross sectional area of $A$ and a length of $L$ and has a resistance of $R$. A second resistor is made from the same material, but the new resistor has half the cross sectional area, $A/2$, and half the length, $L/2$. What is the resistance of the second resistor?

A) $4R$  
B) $2R$  
C) $R$  
D) $R/2$  
E) $R/4$

7. A lightbulb dissipates 60 W of power when attached to a 120 V battery. What is the resistance of the lightbulb?

A) $2 \ \Omega$  
B) $240 \ \Omega$  
C) $0.5 \ \Omega$  
D) $20 \ \Omega$  
E) $120 \ \Omega$
8. The equivalent resistance between points a and b of the following resistor network is closest to

A) 30 Ω  
B) 7.7 Ω  
C) 10 Ω  
D) 14 Ω  
E) 2.7 Ω

Questions 9 and 10 refer to the following circuit.

9. The potential difference between points b and a, $\Delta V = V_a - V_b$, is closest to

A) 12V  
B) 6.7V  
C) 0V  
D) −6.7V  
E) −12V

10. The power being provided by the battery to the circuit is closest to

A) 48 W  
B) 23 W  
C) 29 W  
D) 58 W  
E) 44 W
Questions 11 and 12 refer to the following circuit.

11. For the given circuit and the given current directions, the values of \( I_1 \) and \( I_2 \) are closest to

A) \( I_1 = 0.59 \) A and \( I_2 = 0.70 \) A  
B) \( I_1 = 0.50 \) A and \( I_2 = 0.61 \) A  
C) \( I_1 = -0.68 \) A and \( I_2 = 0.70 \) A  
D) \( I_1 = -0.41 \) A and \( I_2 = 0.70 \) A  
E) \( I_1 = 0.41 \) A and \( I_2 = 0.70 \) A

12. The voltage at point A is closest to

A) \( V_A = -3 \) V  
B) \( V_A = -0.55 \) V  
C) \( V_A = 0 \)  
D) \( V_A = 0.55 \) V  
E) \( V_A = 3 \) V

13. At time \( t = 0 \) the capacitor in the circuit shown below has no charge and the switch is thrown to position a. At what time will the capacitor reach 70% of its maximum charge?

A) 0.023 s  
B) 0.051 s  
C) 0.072 s  
D) 1.02 s  
E) 1.07 s
14. An electron moves in a circular path as shown in a region with a constant magnetic field. In what direction is the magnetic field pointing?

A) into the page
B) out of the page
C) to the left
D) to the right
E) towards the center of the circle

15. A particle with a charge of 0.01 C is moving with a velocity of \( \vec{v} = 1.50 \times 10^3 \hat{i} \) m/s in a region of space with a magnetic field of \( \vec{B} = 0.125 \hat{k} \) T and an electric field of \( \vec{E} = 200 \hat{i} \) N/C. What is the net force acting on the particle?

A) \((2.0\hat{i} - 1.9\hat{j})\) N
B) \((-2.0\hat{i} + 1.9\hat{j})\) N
C) \((2.0\hat{i} + 1.9\hat{j})\) N
D) \((-1.9\hat{i} - 3.8\hat{j})\) N
E) \((1.9\hat{i} - 3.8\hat{j})\) N
Write your answers on this sheet and hand it in when you have completed the exam.

1)

2)

3)

4)

5)

6)

7)

8)

9)

10)

11)

12)

13)

14)

15)