PHY2054 Spring 2019 Exam 1 Review Questions

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Chapter 19: Electric Charges, Forces, and Fields

1. In a hydrogen atom, what is the ratio of the electric force between a proton and an electron to the gravitational force between an electron and a proton? Note that the mass of a proton is $m_p = 1.67 \times 10^{-27}$ kg, the mass of an electron is $m_e = 9.11 \times 10^{-31}$ kg, and a proton and electron are a distance $d = 0.5 \times 10^{-10}$ m apart in a hydrogen atom. *Note that you must use Newton's law of gravitation to compute the gravitational force between any two masses.*

2. 3 charges make up an equilateral triangle. At each vertex of the triangle is an identical charge $q = 3.5$nC, and the side length of the triangle is $L = 5$cm. What is the magnitude of the electric force on any of these charges? *Note that due to the symmetry of this problem, the force should be the same on every charge, so it doesn't matter which charge you compute the force for. Note that since this problem is very symmetric, you can use the symmetry to make solving this problem easier.*

3. Two charges, $q_1 = 3.5\mu$C and $q_2 = -4.7\mu$C, are placed at positions $x_1 = 0$ and $x_2 = 10$cm on an x-axis. Where on the x-axis should a third charge, $q_3 = 1.5\mu$C, be placed such that the net force on q_3 is zero?

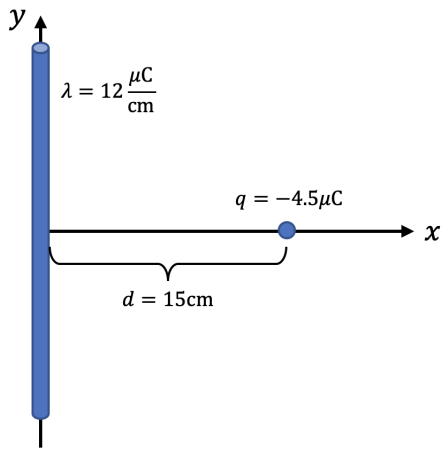

Figure for Problem 4

4. As illustrated above, an infinitely long wire, with a linear charge density $\lambda = 12\mu$C/cm, runs along the y-axis. If a point charge $q = -4.5\mu$C is placed 15cm along the x-axis from the wire, what is the electric force on q, both magnitude and direction?

5. A spherical conductor, with a charge of $Q = 15\text{nC}$, has a radius of 25mm. A point charge, $q = -4.5\mu\text{C}$, is placed 5cm from the surface of the spherical conductor. What is the electric force on q?

6. Two charges, $q_1 = 1.8\text{nC}$ and $q_2 = -4.2\text{nC}$, are placed at positions $x_1 = 0$ and $x_2 = 10\text{cm}$ on an x-axis. Define three regions: region I for $x < 0$, region II for $0 < x < 10\text{cm}$, and region III for $x > 10\text{cm}$. In which region would the net electric field due to q_1 and q_2 be zero? *Note that, technically, the net electric field is zero at $x = \infty$ and $x = -\infty$; these are known as trivial solutions, and are not considered answers to this question.*

7. Which of the following is true for conductors?

   (a) Charges will be spread throughout a conductor and the electric field will be zero within the conductor.

   (b) Charges will be spread throughout a conductor and the electric field will be non-zero within the conductor.

   (c) Charges will be on the surface of a conductor and the electric field will be zero within the conductor.

   (d) Charges will be on the surface of a conductor and the electric field will be non-zero within the conductor.

8. A cube, 5cm×7cm×9cm in dimension, encloses three charges: $q_1 = 5\mu\text{C}$, $q_2 = -2\mu\text{C}$, and $q_3 = 1.5\mu\text{C}$. What is the total flux through the cube?

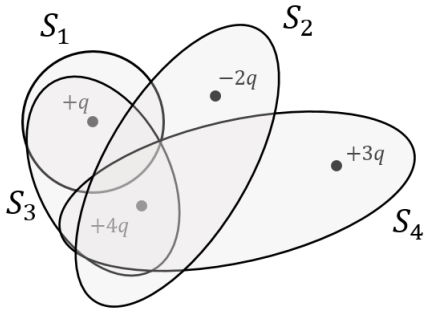

Figure for Problem 9

9. Which surface in the above figure has the largest flux passing through it?

   (a) S_1

   (b) S_2

   (c) S_3

   (d) S_4

10. Two infinitely large sheets of charge, with surface charge densities $\sigma_1 = +7\ \text{nC/m}^2$ and $\sigma_2 = -3\ \text{nC/m}^2$, are situated such that they are parallel to each other and separated by 15mm. What is the net electric field between the two plates?

Chapter 20: Electric Potential and Electric Potential Energy

1. How much work will it take to assemble 4 identical charges, $q = 4.5n\text{C}$, into a square with a side length of $L = 9\text{cm}$?

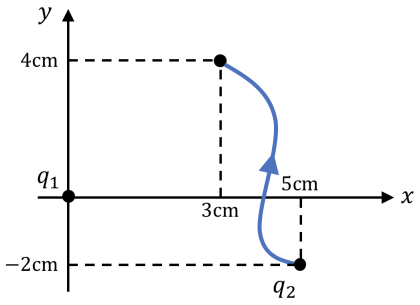

Figure for Problem 2

2. A charge $q_1 = 2.5\mu\text{C}$ is placed at the origin. A second charge $q_2 = -3.7\mu\text{C}$, with a mass $m_2 = 1.7 \times 10^{-10}$ kg, is moved from its initial position to a final position along the path shown in the figure above.

   (a) How much work is done by the electric force on q_2 along the path taken?

   (b) If q_2 was initially at rest, what would its speed be after traveling along the path illustrated in the figure?

3. A charge $q_1 = -3.9\text{nC}$ is initially at the origin of a coordinate system, while a second charge $q_2 = 5.2\text{nC}$ is fixed 30cm to the left and 10cm below the origin. If q_1 is moved 15cm to the right, then 30cm up, and then along a diagonal back to the origin, how much work is done by the electrical force on q_1 during the entire trip?

4. A charge $q = -3.6\mu\text{C}$ moves from point A, where the electric potential is $\phi_A = 5\text{V}$, to point B, where the electric potential is $\phi_B = 10\text{V}$.

   (a) What electric potential energy does q have at point A? At point B?

   (b) What is the change in electric potential q experiences moving from point A to point B?

   (c) How much work does the electric force do on q when it moves from point A to point B?

5. A free electron will always move towards:

   (a) High potential energy and high potential

   (b) High potential energy but low potential

   (c) Low potential energy but high potential

   (d) Low potential energy and low potential

6. Charges are separated such that all negative charges accumulate at point A and all positive charges accumulate at point B. Which of the following statements is true?

   (a) The electric field points from A to B, with A being the point of low potential

   (b) The electric field points from A to B, with B being the point of low potential

   (c) The electric field points from B to A, with A being the point of low potential

   (d) The electric field points from B to A, with B being the point of low potential

7. What are the shapes of the equipotential surfaces for the following charge distributions?

   (a) A point charge

   (b) A spherical charge

   (c) An infinite line of charge

   (d) An infinite sheet of charge

8. A point charge $q = -2\mu$C is placed at the origin of a coordinate system. Point A is located at $x = 3$cm and $y = 0$, while point B is located at $x = 0$ and $y = 8$cm.

   (a) What is the potential at A due to q? What about at B?

   (b) What is the magnitude of the potential difference between points A and B?

   (c) What is the magnitude of the voltage between points A and B?

9. A parallel plate capacitor has a plate area of 5×10^{-4} m^2 and a plate separation of 8mm. If the capacitor is charged to $Q = 17\mu$C, what is the:

   (a) Capacitance?

   (b) Voltage accross the capacitor?

   (c) Electric field within the capacitor?

Chapter 21: Electric Current and Direct-Current Circuits

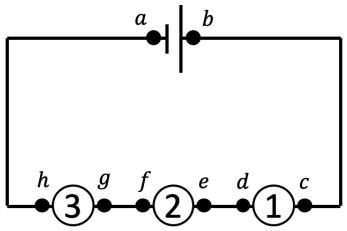

Figure for Problem 1

1. A battery and 3 circuit elements are connected in a circuit, as shown in the figure above. The potential difference from a to b is 10V, the potential difference from c to d is -2V, and the potential difference from g to h is -3V. If we assume that the potential difference across a wire is zero,

   (a) What is the potential difference from e to f?

   (b) What is the potential difference from h to a?

2. A 5μF capacitor, whose plate separation is 1mm, is connected to a 12V battery. When the capacitor is fully charged,

   (a) What is the charge on the capacitor?

   (b) What is the electric field within the capacitor?

3. How much work must be done by an 8V battery to fully charge a 2.5nF capacitor?

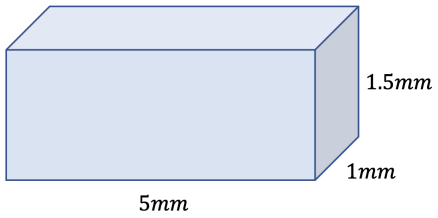

Figure for Problem 4

4. A conductor with a resistivity of 1.2×10^{-6} Ωm is shaped as shown in the above figure. What is the maximum resistance of the above conductor?

5. If the resistor described in Problem 4 is connected to a 9V battery,

   (a) What voltage is across the resistor?

   (b) How much current is produced by the battery?

   (c) What is the electric field in the resistor?

6. A resistor has a current of 5A when connected to a 5V battery. What is the resistance of the resistor?

7. A 15Ω resistor is connected to a 9V battery.

   (a) How much power is being produced by the battery?

   (b) How much heat is produced by the resistor in 3s?

Answers

Chapter 19

1. $F_{\text{electric}}/F_{\text{gravity}} = 2.27 \times 10^{39}$
2. 7.63×10^{-5} N
3. $x_3 = -63$cm
4. 648N, in the $-x$ direction
5. 0.11N
6. Region I
7. (c)
8. 5.08×10^5 Nm^2/C
9. (d)
10. 565 N/C

Chapter 20

1. 8.93×10^{-6} J
2. (a) ...
   (b) ...
3. $W = 0$
4. (a) -18μJ at A, -36μJ at B
   (b) $\Delta\phi_{A\to B} = 5$V
   (c) $W_{A\to B} = 18\mu$J
5. (c)
6. (c)
7. (a) Spherical
   (b) Spherical
   (c) Cylindrical
   (d) Rectangular
8. (a) -5.99×10^5 V at A, -2.25×10^5 V at B
   (b) 3.74×10^5 V
   (c) 3.74×10^5 V
9. (a) 5.53×10^{-13} F
   (b) 3.07×10^7 V
   (c) 3.84×10^9 N/C

Chapter 21

1. (a) -5V
   (b) 0V
2. (a) 6×10^{-5} C
   (b) $12,000$ N/C
3. 8×10^{-8} J
4. 0.004Ω
5. (a) 9V
   (b) 2250A
   (c) 1800 N/C
6. 1Ω
7. (a) 5.4W
   (b) 16.2J