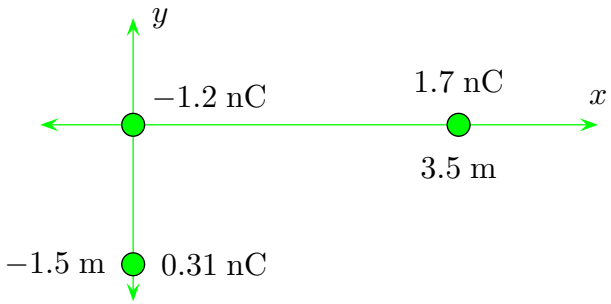
This print-out should have 25 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering.

001 (part 1 of 2) 10.0 points

Three charges are arranged as shown in the figure.



Find the magnitude of the electrostatic force on the charge at the origin. The value of the Coulomb constant is $8.98755 \times 10^9\ \mathrm{N \cdot m^2/C^2}$.

Answer in units of nN.

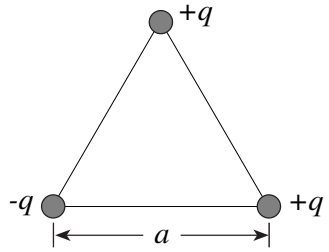
002 (part 2 of 2) 10.0 points

What is the angle θ between the electrostatic force on the charge at the origin and the positive x-axis? Answer in degrees as an angle between $-180°$ and $180°$ measured from the positive x-axis, with counterclockwise positive.

Answer in units of °.

003 10.0 points

Three point charges, two positive and one negative, each having a magnitude of 18 μC are placed at the vertices of an equilateral triangle (50 cm on a side).

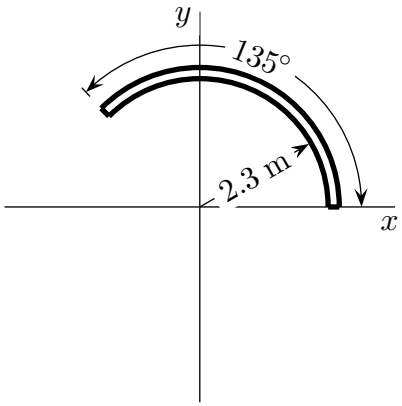


What is the magnitude of the electrostatic force on one of the positive charges? The value of the Coulomb constant is $8.98755 \times 10^9\ \mathrm{N \cdot m^2/C^2}$.

Answer in units of N.

004 10.0 points

A circular arc has a uniform linear charge density of 3 nC/m.

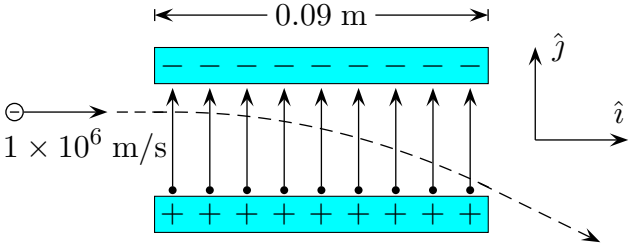


What is the magnitude of the electric field at the center of the circle along which the arc lies? The value of the Coulomb constant is $8.98755 \times 10^9\ \mathrm{N \cdot m^2/C^2}$.

Answer in units of N/C.

005 (part 1 of 3) 10.0 points

An electron traveling at 1×10^6 m/s enters a 0.09 m region with a uniform electric field of 146 N/C , as in the figure.



Find the magnitude of the acceleration of the electron while in the electric field. The mass of an electron is 9.109×10^{-31} kg and the fundamental charge is 1.602×10^{-19} C .

Answer in units of $\mathrm{m/s^2}$.

006 (part 2 of 3) 10.0 points

Find the time it takes the electron to travel through the region of the electric field, assuming it doesn't hit the side walls.

Answer in units of s.

007 (part 3 of 3) 10.0 points

What is the magnitude of the vertical displacement Δy of the electron while it is in the electric field?

Answer in units of m.

008 (part 1 of 2) 10.0 points

A strong lightning bolt transfers an electric charge of about 30 C to Earth (or *vice versa*).

How many electrons are transferred? Avogadro's number is 6.022×10^{23} /mol, and the elemental charge is 1.602×10^{-19} C.

009 (part 2 of 2) 10.0 points

If each water molecule donates one electron, how much water is ionized in the lightning? One mole of water has a mass of 18.1 g/mol.

Answer in units of g.

010 10.0 points

Four point charges, each of magnitude 2.21 μC, are placed at the corners of a square 65.4 cm on a side.

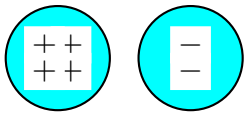
If three of the charges are positive and one is negative, find the magnitude of the force experienced by the negative charge. The value of Coulomb's constant is 8.98755×10^9 N $\cdot$ m^2/C^2.

Answer in units of N.

011 (part 1 of 2) 10.0 points

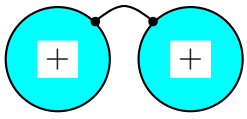
Two conducting spheres have identical radii. Initially they have charges of opposite sign and unequal magnitudes with the magnitude of the positive charge larger than the magnitude of the negative charge. They attract each other with a force of 0.258 N when separated by 0.5 m.

Initial



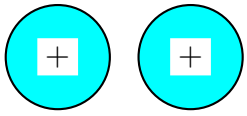
The spheres are suddenly connected by a thin conducting wire, which is then removed.

Connected



Now the spheres repel each other with a force of 0.042 N.

Final



What is the magnitude of the positive charge?

Answer in units of C.

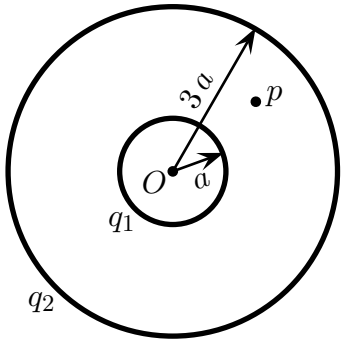
012 (part 2 of 2) 10.0 points

What is the negative charge?

Answer in units of C.

013 10.0 points

Consider two concentric spherical conducting shells. The inner shell has radius a and charge q_1 on it, while the outer shell has radius $3\,a$ and charge q_2 on it.



Determine the electric field E at p, where the distance $Op = 2\,a$.

1. $E = \dfrac{q_1}{12\,\pi\,\epsilon_0\,a^2}$

2. $E = \dfrac{q_1}{4\,\pi\,\epsilon_0\,a^2}$

3. $E = \dfrac{q_1}{16\,\pi\,\epsilon_0\,a^2}$

4. $E = \dfrac{q_1}{14\,\pi\,\epsilon_0\,a^2}$

5. $E = \dfrac{q_1}{18\,\pi\,\epsilon_0\,a^2}$

6. $E = \dfrac{q_1}{6\,\pi\,\epsilon_0\,a^2}$

7. $E = \dfrac{q_1}{20\,\pi\,\epsilon_0\,a^2}$

8. $E = \dfrac{q_1}{8\,\pi\,\epsilon_0\,a^2}$

014 (part 1 of 2) 10.0 points

An electron and a proton are each placed at rest in an electric field of 232 N/C.

What is the velocity of the electron 20.9 ns after being released? Consider the direction parallel to the field to be positive. The fundamental charge is 1.602×10^{-19} C and the mass of an electron is 9.109×10^{-31} kg.

Answer in units of m/s.

015 (part 2 of 2) 10.0 points

What is the velocity of the proton 20.9 ns after being released? The mass of the proton is 1.6726×10^{-27} kg.

Answer in units of m/s.

016 10.0 points

A 9.1 g piece of Styrofoam carries a net charge of -0.5 μC and floats above the center of a very large horizontal sheet of plastic that has a uniform charge density on its surface.

What is the charge per unit area on the plastic sheet? The acceleration due to gravity is 9.8 m/s^2 and the permittivity of free space is 8.85419×10^{-12} C^2/N/m^2.

Answer in units of μC/m^2.

017 10.0 points

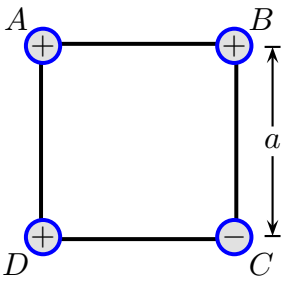
Two electrons in an atom are separated by 1.3×10^{-10} m, the typical size of an atom.

What is the force between them? The Coulomb constant is 9×10^9 N $\cdot$ m^2/C^2.

Answer in units of N.

018 (part 1 of 2) 10.0 points

Consider a square with side a. Four charges $+q$, $+q$, $-q$, and $+q$ are placed at the corners A, B, C, and D, respectively.



What is the magnitude of the electric field at D due to the charges at A, B, and C?

1. $\|\vec{E}\| = \frac{5}{2}\,\frac{k\,q}{a^2}$

2. $\|\vec{E}\| = \frac{7}{2}\,\frac{k\,q}{a^2}$

3. $\|\vec{E}\| = 3\,\frac{k\,q}{a^2}$

4. $\|\vec{E}\| = \frac{3}{4}\,\frac{k\,q}{a^2}$

5. $\|\vec{E}\| = \frac{9}{4}\,\frac{k\,q}{a^2}$

6. $\|\vec{E}\| = \frac{3}{2}\,\frac{k\,q}{a^2}$

7. $\|\vec{E}\| = \sqrt{2}\,\frac{k\,q}{a^2}$

8. $\|\vec{E}\| = 2\,\frac{k\,q}{a^2}$

9. $\|\vec{E}\| = \frac{k\,q}{a^2}$

10. $\|\vec{E}\| = \frac{5}{4}\,\frac{k\,q}{a^2}$

019 (part 2 of 2) 10.0 points

The polar angle of the corresponding electric field vector at D is within the range

1. $180^\circ \le \theta < 225^\circ$

2. $45^\circ \le \theta < 90^\circ$

3. $270^\circ \le \theta < 315^\circ$

4. $315^\circ \le \theta < 360^\circ$

5. $90^\circ \le \theta < 135^\circ$

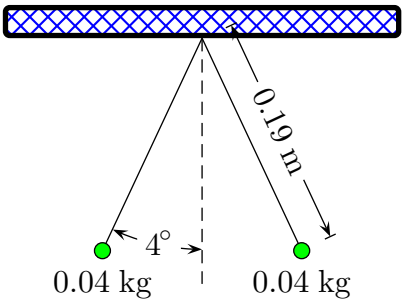
6. $225^\circ \le \theta < 270^\circ$

7. $135^\circ \le \theta < 180^\circ$

8. $0^\circ \le \theta < 45^\circ$

020 10.0 points

Two identical small charged spheres hang in equilibrium with equal masses as shown in the figure. The length of the strings are equal and the angle (shown in the figure) with the vertical is identical.



Find the magnitude of the charge on each sphere. The acceleration of gravity is 9.8 m/s^2 and the value of Coulomb's constant is 8.98755×10^9 N $\cdot$ m^2/C^2 .

Answer in units of C.

021 10.0 points

A balloon rubbed against denim gains a charge of -2.0 μC.

What is the electric force between the balloon and the denim when the two are separated by a distance of 3.0 cm? (As-

sume that the charges are located at a point.) The value of the Coulomb constant is 8.98755×10^9 N $\cdot$ m^2/C^2.

Include direction of the force.

Answer in units of N.

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022 10.0 points

An object with a net charge of 37 μC is placed in a uniform electric field of 608 N/C, directed vertically. What is the mass of this object if it floats in this electric field? The acceleration due to gravity is $9.81 m/s^2$.

Answer in units of kg.

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023 10.0 points

Two identical positive charges exert a repulsive force of 6.3×10^{-9} N when separated by a distance 3.9×10^{-10} m.

Calculate the charge of each. The Coulomb constant is 8.98755×10^9 N $\cdot$ m^2/C^2.

Answer in units of C.

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024 (part 1 of 2) 10.0 points

An electron is accelerated by a constant electric field of magnitude 282 N/C.

Find the magnitude of the acceleration of the electron. The mass of an electron is 9.109×10^{-31} kg and the elemental charge is 1.6×10^{-19} C.

Answer in units of m/s^2.

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025 (part 2 of 2) 10.0 points

Find the electron's speed after 6.51×10^{-8} s, assuming it starts from rest.

Answer in units of m/s.