

PH 221 Homework Assignment Chapter on Charge and E Field – 34 Problems Total

1. What is the magnitude of the electric force between the nucleus of copper (atomic number = 29) and electron which is located a distance of 7.40×10^{-11} m away from the nucleus?

Solution for Problem 1

2. How many electrons have been removed for an object to have a net charge of $+47.0 \mu\text{C}$?

Solution for Problem 2

3. What is the repulsive electrical force between two protons which are located a distance of 6.00×10^{-15} m apart within the nucleus?

Solution for Problem 3

4. A person scuffling their feet on a shag carpet on a day with low humidity accumulates a net charge of -57.6 mC .

Solution for Problem 4

5. What is the total charge of all the protons in a 10.0 kg bar of platinum? (Platinum has an atomic number of 78 and an atomic mass of 195.084 u. $1 \text{ u} = 1.66 \times 10^{-27} \text{ kg}$)

Solution for Problem 5

6. Calculate the ratio of the electrical force between the electron and the proton in a hydrogen atom to the gravitational force between the same electron and proton in the same hydrogen atom.

Solution for Problem 6

7. Two negative point charges are a fixed distance apart. The sum of their charges is Q_{Total} . What must be charge for each one (Q_1 and Q_2) in order that:

- (a) The magnitude of the electric force between them is a maximum?
- (b) The magnitude of the electric force between them is a minimum?

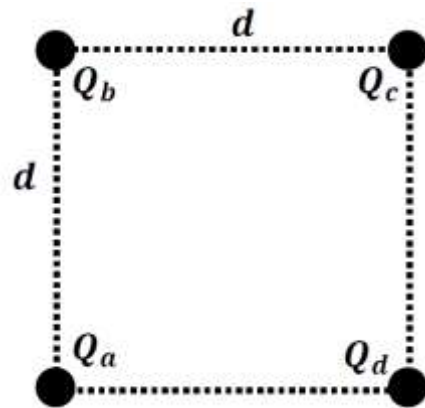
Solution for Problem 7

8. Two small nonconducting spheres have a total charge of $+120.0 \mu\text{C}$. When the spheres are placed a distance of 2.24 m apart the force each sphere exerts on the other has a magnitude of 5.73 N . What is the charge on each sphere if

- (a) The electric force between them is repulsive?
- (b) The electric force between them is attractive?

Solution for Problem 8

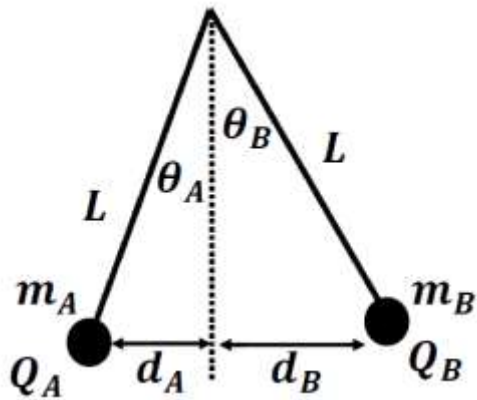
9. Four identical charges ($Q = -6.67 \text{ mC}$) are placed on the corners of a square which has a side length of $d = 0.200 \text{ m}$. What is the net force acting on Charge “d”?



Solution for Problem 9

10. A charge Q is transferred from an initially uncharged object to an identical object also initially uncharged a distance of $1.30 \times 10^{-2} \text{ m}$ away. The force of attraction between the two objects is found to be $2.30 \times 10^{-4} \text{ N}$. How many electrons were transferred from the first object to the second object?

Solution for Problem 10



11. Two small spheres are hanging from identical massless, stretchless, and unbreakable cords both of length L . Sphere A has a mass m_A and a charge Q_A . Sphere B has a mass m_B and a charge Q_B . Due to the charges an electrical force causes the two spheres to be hanging at angles θ_A and θ_B as shown. The distance between the two spheres is $d = d_A + d_B$.

- (a) If $Q_A = Q$, $Q_B = 2Q$ and $m_A = m_B = m$, find the ratio of θ_A/θ_B .
- (b) For this same situation as (a) find the distance d between the two spheres.
- (c) If $Q_A = Q$, $Q_B = 2Q$, $m_A = m$, and $m_B = 2m$, find the ratio of θ_A/θ_B .
- (d) For this same situation as (c) find the distance d between the two spheres.

Solution for Problem 11

12. An electrical force of $3.45 \times 10^{-15} \text{ N}$ ($\widehat{\text{North}}$) is created when an electron is placed inside a uniform electric field. What is the magnitude and direction of the electric field?

Solution for Problem 12

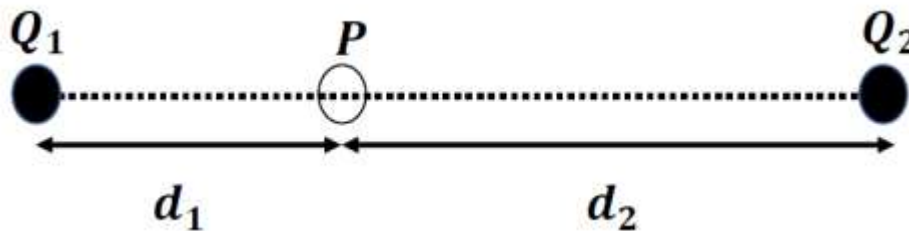
13. A $+4.67 \text{ mC}$ charge is placed into a uniform electric field given by

$$\vec{E} = 9.84 \times 10^7 \text{ N/C } (\widehat{k})$$

What is the electric force (vector) that acts on the charge?

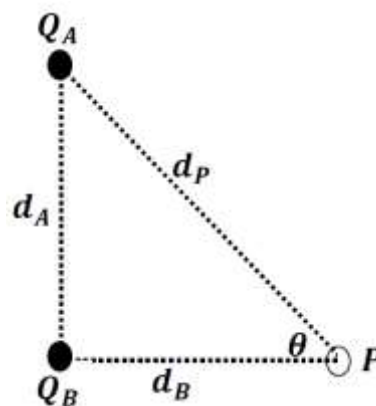
Solution for Problem 13

14. Determine the magnitude and direction of the electric field at the point (P) indicated below due to the two charges shown. $Q_1 = -7.69 \text{ mC}$, $Q_2 = -4.98 \text{ mC}$, $d_1 = 1.34 \times 10^{-3} \text{ m}$, and $d_2 = 2.21 \times 10^{-3} \text{ m}$.



Solution for Problem 14

15. Two charges are located on two points of a triangle as shown in the figure on the right. $Q_A = -9.13 \mu\text{C}$ and $Q_B = +7.33 \mu\text{C}$. $d_A = 7.45 \times 10^{-5} \text{ m}$ and $d_B = 5.59 \times 10^{-5} \text{ m}$. What is the magnitude and direction of the Electric Field at point P due to these two charges?



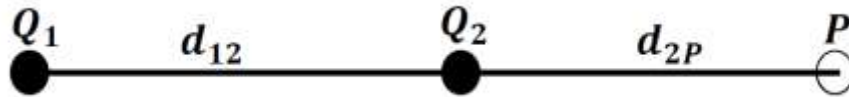
Solution for Problem 15

16. Two charges are located along the y axis. Charge A is $Q_A = -33.3 \text{ mC}$ and Charge B is $Q_B = -24.6 \text{ mC}$. The distance from Charge A to point P is $d_A = 2.07 \times 10^{-2} \text{ m}$. The electric field due to these two charges is zero at point P. What is the distance from Charge B to point P?



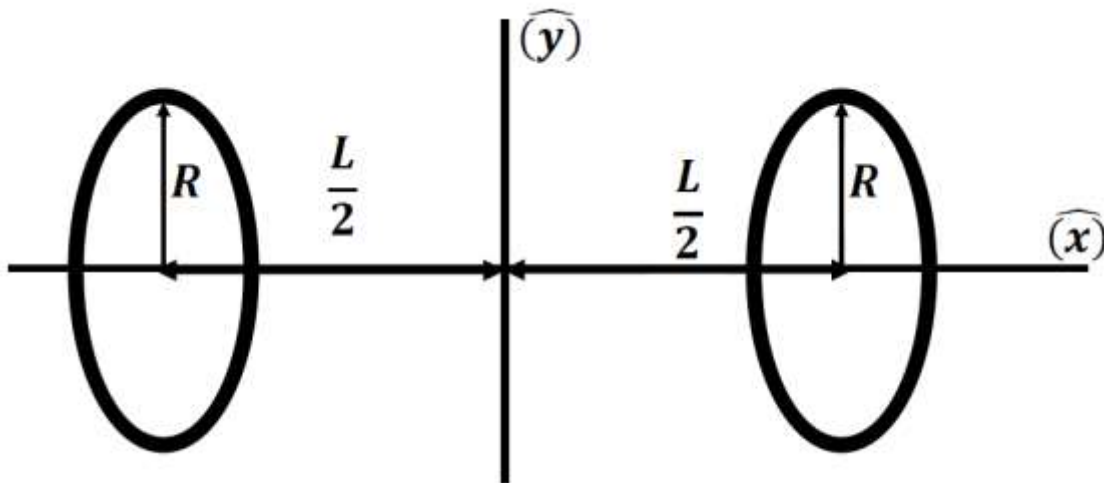
Solution for Problem 16

17. As shown below there are two charges $Q_1 = +96.8 \text{ mC}$ and $Q_2 = -52.9 \text{ mC}$. At a point P the electric field due to these two charges is found to be zero! The distance from point P to charge Q_2 is $d_{2P} = 17.7 \times 10^{-3} \text{ m}$. What is the distance between charges Q_1 and Q_2 which is referred to as d_{12} in the diagram?

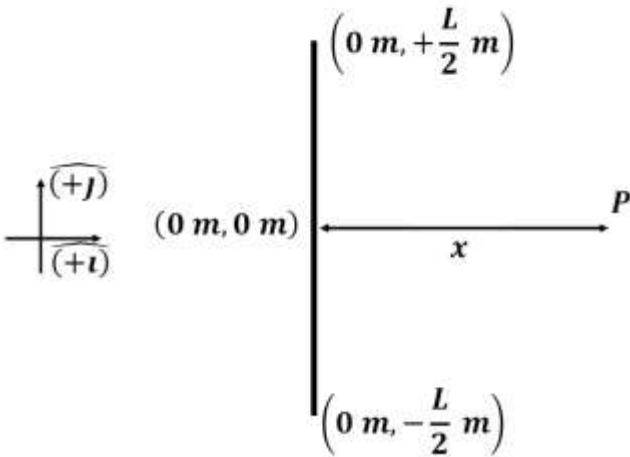


Solution for Problem 17

18. As shown below, two parallel circular rings of radius R are centered on the x – axis and separated by a distance of L . Each ring has a charge Q uniformly distributed around it. Find the magnitude and direction of the electric field created by these two rings at points along the x – axis.



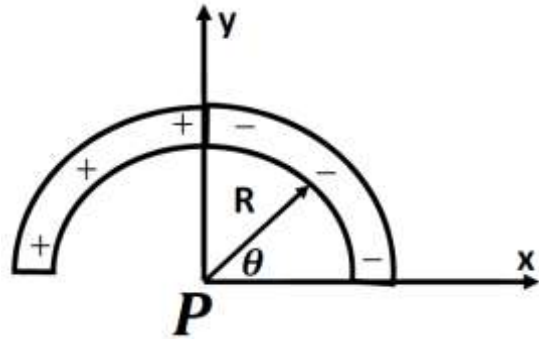
Solution for Problem 18



19. A wire has a length of L and runs along the y – axis as shown on the left. The wire has a total charge of Q on it which is uniformly distributed providing a linear charge density of $\lambda = Q/L$. What is the magnitude and direction of the electric field along the x – axis. Assume the wire is centered with the x – axis so that it extends $\pm L/2$ from the x – axis.

Solution for Problem 19

20. A nonconductive polymer is shaped into a semicircle of radius R as shown on the right. It has a nonuniform charge distributed on it that follows the relationship given by the linear charge density function $\lambda = \lambda_0 \cos(\theta)$. λ_0 is a negative constant with units of C/m . P is the point at the center of the semi-circle. Recall that $\cos(\theta) > 0$ for $0^\circ \leq \theta \leq 90^\circ$ and $\cos(\theta) < 0$ for $90^\circ \leq \theta \leq 180^\circ$.

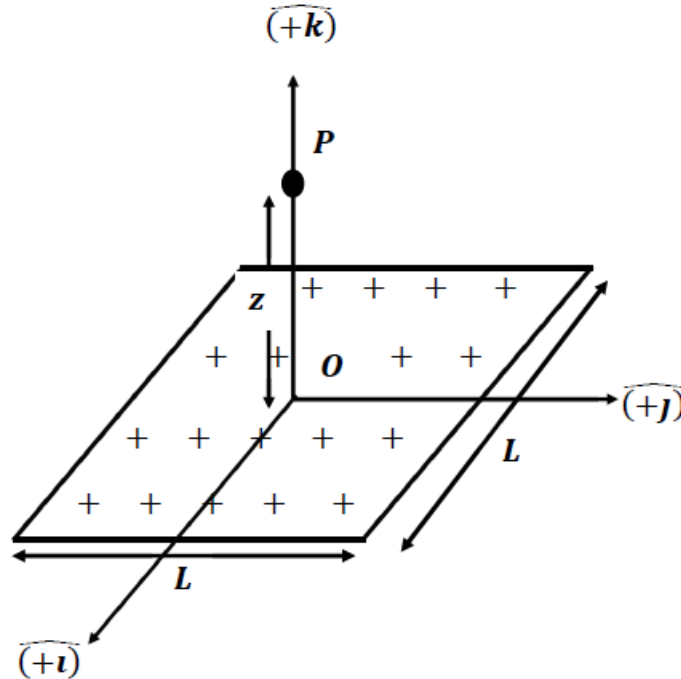


- (a) Find the magnitude and direction of the electric field at point P .
- (b) Determine the magnitude and direction the electric field will create to act on an electron placed at point P . If $R = 1.40 \times 10^{-2}\text{ m}$ and $\lambda_0 = -6.98 \times 10^{-3}\text{ C/m}$.

Solution for Problem 20

21. Consider a large plane with sides $L \times L$ which lies in the x - y plane as shown below. The plane has charge uniformly distributed along its surface with an area charge density

$\sigma = Q/A = Q/L^2$ which has units of (C/m^2) . Point P lies along the z axis above the center of the plane.



Determine the electric field due to the charged plane at point P assuming the plane is infinitely large (i.e. $L \rightarrow \infty$). Use two methods:

- (a) Consider the plane being composed of long straight wires running along the x – axis. Sum them up along the y – axis.

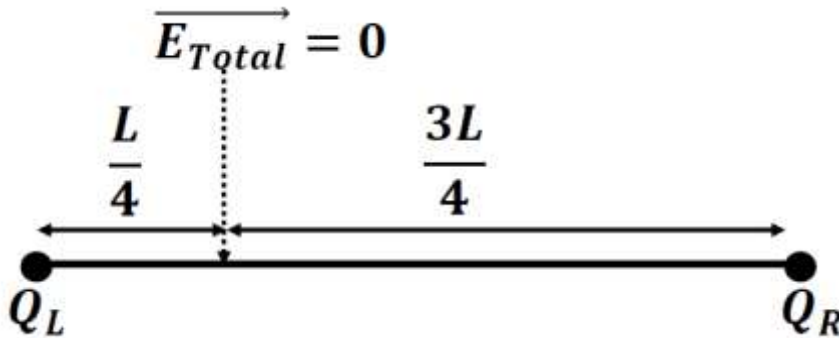
Hint: review Homework Problem 19.

- (b) Consider the plane being composed of concentric rings of charge centered on the x - y origin. Then sum them up along the radius.

Hint: review Homework Problem 18.

Solution for Problem 21

22. Consider two charges shown below, Q_L and Q_R separated by a distance of L . At a point shown below $\frac{1}{4}L$ from Q_L and $\frac{3}{4}L$ from Q_R the total electric field is found to be zero. What is the ratio of the two charges Q_L/Q_R ?



Solution for Problem 22

23. A proton has an initial velocity designated by: $\vec{v}_0 = 6.24 \times 10^5 \text{ m/s } (\widehat{k})$. It enters an electric field which can be described by: $\vec{E} = (3.09 \widehat{i}) + 2.91 \widehat{k}) \times 10^{-3} \text{ N/C}$.

- (a) Determine an expression for the acceleration (vector) of the proton as a function of time
- (b) Find the angle of the proton's velocity relative to its original direction (\widehat{k}) at a time of 2.00 s.

Solution for Problem 23

24. An electron is traveling with an initial velocity of $\vec{v}_0 = 8.84 \times 10^4 \text{ m/s } (\widehat{West})$ when it enters an electric field that is parallel to this initial velocity. The electron is brought to rest by this electric field, after traveling a distance of $1.45 \times 10^{-2} \text{ m } (\widehat{West})$.

- (a) What is the direction the electric field is pointing in?
- (b) What is the strength of the electric field?

Solution for Problem 24

25. A proton is moving through space with an initial velocity of

$$\vec{v}_0 = 2.21 \text{ m/s } \hat{j} - 4.14 \text{ m/s } \hat{k}$$

At time ($t = 0.00 \text{ s}$), the proton is at location ($\vec{S}_0 = 1.20 \text{ m } \hat{i} + 3.93 \text{ m } \hat{j} - 2.55 \text{ m } \hat{k}$) when it enters an electric field described by

$$\vec{E} = -4.00 \times 10^{-8} \text{ N/C } \hat{i} + 6.12 \times 10^{-8} \text{ N/C } \hat{k}$$

What is the proton's position at time ($t = 3.40 \text{ s}$)?

Solution for Problem 25

26. An electric dipole consists of charges $+Q$ and $-Q$ which are separated by a distance d . Assume $Q = 3.74 \times 10^{-4} \text{ C}$, $d = 5.68 \times 10^{-3} \text{ m}$. The dipole is placed into an electric field with a strength of $E = 7.81 \times 10^5 \text{ N/C}$. Assume the dipole direction, which goes from the negative charge towards the positive charge, is initially parallel to the electric field.

- (a) Calculate the value of the dipole moment.
- (b) What is the torque on the dipole when it is parallel to the electric field?
- (c) What is the torque on the dipole when it is making a 60.0° angle with the direction of the electric field?
- (d) What is the torque on the dipole when it is antiparallel to the electric field?
- (e) How much work is required for an external agent to rotate the dipole from being parallel to the electric field to being antiparallel to the electric field?

Solution for Problem 26

27. A molecule has an electric dipole moment of 4.78×10^{-30} C m. The two atoms are separated by a distance of 1.76×10^{-10} m.

- (a) Determine the net charge on each atom.
- (b) Is this a multiple of the fundamental electron charge?
- (c) If not, explain how this is possible.
- (d) What is the maximum torque this electric dipole would experience if it were placed within an electric field with a strength of 8.71×10^4 N/C?
- (e) How much energy would be required to rotate the dipole from its lowest energy state to an orientation in which the electric dipole is rotated 60.0° from this lowest energy state?

Solution for Problem 27

28. The Earth's electric field can be approximated as charges uniformly distributed through the Earth's volume resulting in a field of strength approximately 150 N/C which points inward towards the center of the Earth. What is the amount of the net charge of the Earth and is it positive or negative?

Solution for Problem 28

29. If instead of the gravitational force keeping the Moon in orbit around the Earth, what if it were the electrical force? Assume identical but oppositely signed charges were distributed on the Earth and the Moon. How large would the charge have to be in magnitude for the Moon to continue to orbit the Earth at the same distance?

Solution for Problem 29

30. In the Bohr model of the Hydrogen atom, the electron moves along a circular orbit around the proton. What is the speed of the electron in the ground state of hydrogen when the electron is at the Bohr radius (5.29×10^{-11} m)?

Solution for Problem 30

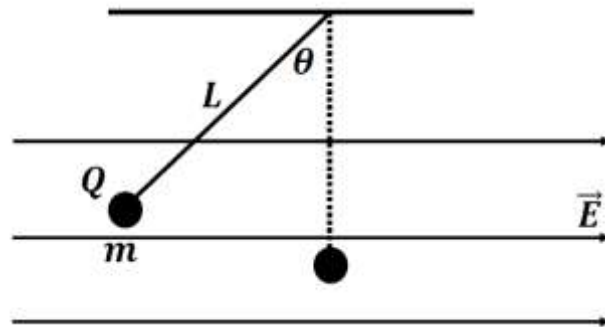
31. When a spark appears in a medium (say, air) then the local electrical field has exceeded a value known as the break-down electrical field for the medium. For dry air (think of winter time), the break-down field is approximately $3.00 \times 10^6 \text{ N/C}$. Consider a small elastic balloon which has accumulated static charge. If the balloon is approximately spherical with a radius of $2.75 \times 10^{-2} \text{ m}$, how much charge is needed before the balloon “pops” due to creating a spark across its diameter?

Solution for Problem 31

32. Polystyrene is a common material used in packing items to protect them from damage during shipping. Polystyrene can accumulate charge quite easily which creates a static electricity force between polystyrene and other items. When unpacking, you often have small bits of polystyrene sticking together as well as sticking to the packed object and other items. Consider two small spherical balls of polystyrene are electrically attached. Let’s assume the electrical force is equal to the weight of one sphere. Consider the two spheres to be identical and have radii of $3.34 \times 10^{-3} \text{ m}$ and each has charge of magnitude of $5.16 \times 10^{-10} \text{ C}$. Obviously since they are attracted, they have opposite signs for their charges. What is the mass density of the polystyrene used?

Solution for Problem 32

33. An object shown on the right has a mass ($m = 5.56 \times 10^{-3} \text{ kg}$) and has been charged to ($Q = -7.68 \times 10^{-6} \text{ C}$). The object is connected to a massless, stretchless and unbreakable cord of length ($L = 37.9 \times 10^{-2} \text{ m}$). When the angle shown in the figure is ($\theta = 19.0^\circ$), the object is found to be at rest in the electric field shown in the diagram. What is the magnitude of the electric field?



Solution for Problem 33

34. There are three identical conducting solid spheres each has a mass m , charge Q , and radii of R . Spheres A and B are initially located near each other with a distance of d from the center of Sphere A to the center of Sphere B.

- (a) What is the electrical force Sphere A exerts on Sphere B?
- (b) Sphere C is brought into physical contact with Sphere B and the two spheres are allowed to equilibrate charges. Sphere C is then moved away. What is the electrical force Sphere A exerts on Sphere B at this time?
- (c) Sphere C is now brought into physical contact with Sphere A and the two spheres are allowed to equilibrate charges. Sphere C is then moved away. What is the electrical force Sphere A now exerts on Sphere B?

Solution for Problem 34

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