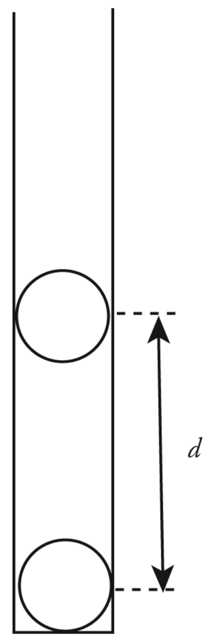
AP Physics Ch 25-29 Test **Name**___________________________________ **#:**__

**MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.**

1. One very small uniformly charged plastic ball is located directly above another such charge in a test tube as shown in the figure. The balls are in equilibrium a distance $d$ apart. If the charge on each ball is doubled, the distance between the balls in the test tube would become




A) $\sqrt{2}d$. B) $2d$. C) $8d$. D) $4d$.

2. Two identical small charged spheres are a certain distance apart, and each one initially experiences an electrostatic force of magnitude $F$ due to the other. With time, charge gradually leaks off of both spheres. When each of the spheres has lost half its initial charge, the magnitude of the electrostatic force will be
A) $1/8F$. B) $1/2F$. C) $1/4F$. D) $1/16F$.

3. When two point charges are a distance $d$ part, the electric force that each one feels from the other has magnitude $F$. In order to make this force twice as strong, the distance would have to be changed to
A) $d/4$. B) $2d$. C) $d/\sqrt{2}$ D) $d/2$. E) $\sqrt{2}d$.

4. A point charge $Q$ is located a short distance from a point charge $3Q$, and no other charges are present. If the electrical force on $Q$ is $F$, what is the electrical force on $3Q$?
A) $\sqrt{3}F$ B) $3F$ C) $F/\sqrt{3}$ D) $F/3$ E) $F$

5. A positive point charge $Q$ is fixed on a very large horizontal frictionless tabletop. A second positive point charge $q$ is released from rest near the stationary charge and is free to move. Which statement best describes the motion of $q$ after it is released?
A) As it moves farther and farther from $Q$, its speed will decrease.
B) As it moves farther and farther from $Q$, its acceleration will keep increasing.
C) Its speed will be greatest just after it is released.
D) Its acceleration is zero just after it is released.
E) As it moves farther and farther from $Q$, its speed will keep increasing.

6. $X$ and $Y$ are two uncharged metal spheres on insulating stands, and are in contact with each other. A positively charged rod $R$ is brought close to $X$ as shown in Figure (a).

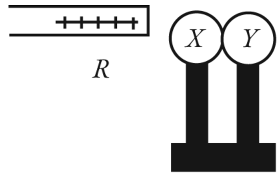



Figure (a)

Sphere $Y$ is now moved away from $X$, as in Figure (b).

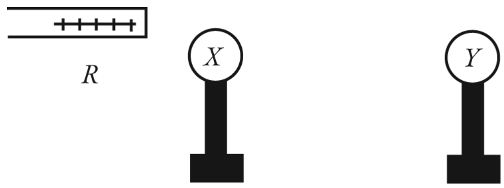



Figure (b)

What are the final charge states of $X$ and $Y$?
A) $X$ is negative and $Y$ is positive.
B) $X$ is neutral and $Y$ is positive.
C) $X$ is positive and $Y$ is neutral.
D) Both $X$ and $Y$ are negative.
E) Both $X$ and $Y$ are neutral.

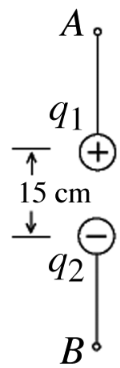
7. A piece of plastic has a net charge of +2.00 μC. How many more protons than electrons does this piece of plastic have? ($e = 1.60 \times 10^{-19}$ C)
A) $2.50 \times 10^{13}$ B) $1.25 \times 10^{13}$ C) $2.50 \times 10^{19}$ D) $1.25 \times 10^{19}$

8. A 1.0-C point charge is 15 m from a second point charge, and the electric force on one of them due to the other is 1.0 N. What is the magnitude of the second charge? ($k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9\ \mathrm{N \cdot m^2/C^2}$)
A) 25 nC B) 10 nC C) 1.0 C D) 25 C E) 0.025 C

9. When two point charges are 2.0 cm apart, each one experiences a 1.0-N electric force due to the other charge. If they are moved to a new separation of 8.0 cm, the electric force on each of them is closest to
A) 16 N. B) 4.0 N. C) 0.063 N. D) 0.25 N. E) 1.0 N.

10. Two identical small conducting spheres are separated by 0.60 m. The spheres carry different amounts of charge and each sphere experiences an attractive electric force of 10.8N. The total charge on the two spheres is -24 μC. The two spheres are now connected by a slender conducting wire, which is then removed. The electric force on each sphere is closest to
A) 3.6 N, repulsive.
B) 3.6 N, attractive.
C) 5.4 N, attractive.
D) 5.4 N, repulsive.
E) zero.

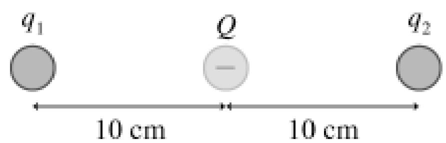
11. Two small insulating spheres are attached to silk threads and aligned vertically as shown in the figure. These spheres have equal masses of 40 g, and carry charges $q_1$ and $q_2$ of equal magnitude 2.0 μC but opposite sign. The spheres are brought into the positions shown in the figure, with a vertical separation of 15 cm between them. Note that you cannot neglect gravity. ($k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9$ N • m$^2$/C$^2$) The tension in the lower thread is closest to




A) 1.8 N. B) 1.6 N. C) 2.0 N. D) 1.2 N. E) 1.4 N.

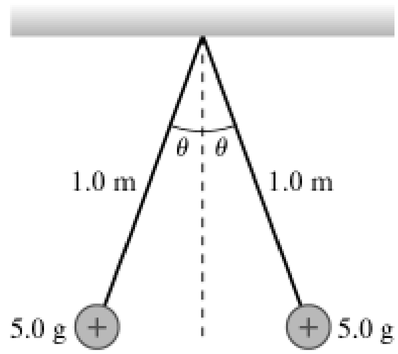
12. A +7.00 μC point charge and −9.00 μC point charge are placed along the $x$-axis at $x$ = 0.000 cm and $x$ = 40.0 cm, respectively. Where must a third charge, $q$, be placed along the $x$-axis so that it does not experience any net electric force due to the other two charges?
A) 0.187 m B) 2.99 m C) −0.187 m D) −0.200 m E) −2.99 m

13. In the figure, all the charges are point charges and the charge in the middle is $Q$ = −3.1 nC. For what charge $q_1$ will charge $q_2$ be in static equilibrium?



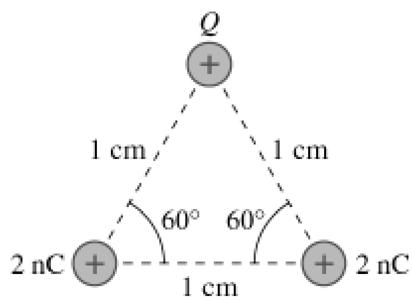

A) 12 nC B) 25 nC C) 6.2 nC D) 3.1 nC

14. The figure shows two tiny 5.0-g spheres suspended from two very thin 1.0-m-long threads. The spheres repel each other after being charged to +91 nC and hang at rest as shown. What is the angle $\theta$? ($k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9\ \mathrm{N \cdot m^2/C^2}$)



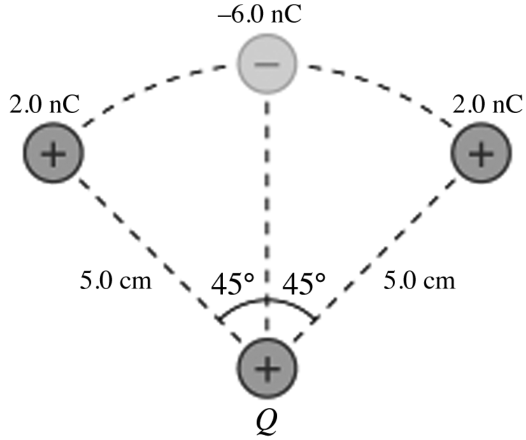

A) 12°　　B) 16°　　C) 4.1°　　D) 8.2°

15. In the figure $Q = 5.8$ nC and all other quantities are accurate to 2 significant figures. What is the magnitude of the force on the charge $Q$? ($k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9\ \mathrm{N \cdot m^2/C^2}$)



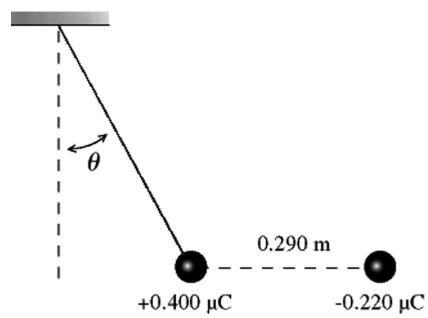

A) $1.2 \times 10^{-3}$ N　　B) $1.8 \times 10^{-3}$ N　　C) $9.0 \times 10^{-4}$ N　　D) $1.0 \times 10^{-3}$ N

16. The point charge at the bottom of the figure is $Q = +17$ nC, and the curve is a circular arc. What is the magnitude of the force on the charge $Q$ due to the other point charges shown? ($k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9\ \mathrm{N \cdot m^2/C^2}$)




A) $1.9 \times 10^{-4}$ N　　B) $1.6 \times 10^{-4}$ N　　C) $1.2 \times 10^{-4}$ N　　D) $2.3 \times 10^{-4}$ N

17. In the figure, a small spherical insulator of mass $6.00 \times 10^{-2}$ kg and charge $+0.400$ μC is hung by a thin wire of negligible mass. A charge of $-0.220$ μC is held 0.290 m away from the sphere and directly to the right of it, so the wire makes an angle $\theta$ with the vertical, as shown. What is the angle $\theta$? ($k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9$ N $\cdot$ m$^2$/C$^2$)




A) 1.70°  B) 0.917°  C) 1.50°  D) 1.30°  E) 1.10°

18. An atomic nucleus has a charge of $+40e$. What is the magnitude of the electric field at a distance of 1.0 m from the center of the nucleus? ($k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9$ N $\cdot$ m$^2$/C$^2$, $e = 1.60 \times 10^{-19}$ C)

A) $5.4 \times 10^{-8}$ N/C
B) $6.0 \times 10^{-8}$ N/C
C) $5.6 \times 10^{-8}$ N/C
D) $6.2 \times 10^{-8}$ N/C
E) $5.8 \times 10^{-8}$ N/C

19. A small glass bead has been charged to 8.0 nC. What is the magnitude of the electric field 2.0 cm from the center of the bead? ($k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9$ N $\cdot$ m$^2$/C$^2$)

A) $1.4 \times 10^{-3}$ N/C  B) $3.6 \times 10^{3}$ N/C  C) $1.8 \times 10^{5}$ N/C  D) $3.6 \times 10^{-6}$ N/C

20. The electric field 1.5 cm from a very small charged object points toward the object with a magnitude of 180,000 N/C. What is the charge on the object? ($k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9$ N $\cdot$ m$^2$/C$^2$)

A) +4.5 nC  B) +5.0 nC  C) −5.0 nC  D) −4.5 nC

21. A metal sphere of radius 10 cm carries a charge of +2.0 μC uniformly distributed over its surface. What is the magnitude of the electric field due to this sphere at a point 5.0 cm outside the sphere's surface? ($k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9$ N $\cdot$ m$^2$/C$^2$)

A) $8.0 \times 10^{5}$ N/C
B) $4.0 \times 10^{7}$ N/C
C) $4.0 \times 10^{5}$ N/C
D) $4.2 \times 10^{6}$ N/C
E) $8.0 \times 10^{7}$ N/C

22. A proton is placed in an electric field of intensity 700 N/C. What are the magnitude and direction of the acceleration of this proton due to this field? ($m_{proton} = 1.67 \times 10^{-27}$ kg, $e = 1.60 \times 10^{-19}$ C)

A) $6.71 \times 10^{10}$ m/s$^2$ opposite to the electric field
B) $67.1 \times 10^{10}$ m/s$^2$ in the direction of the electric field
C) $6.71 \times 10^{9}$ m/s$^2$ opposite to the electric field
D) $67.1 \times 10^{10}$ m/s$^2$ opposite to the electric field
E) $6.71 \times 10^{10}$ m/s$^2$ in the direction of the electric field

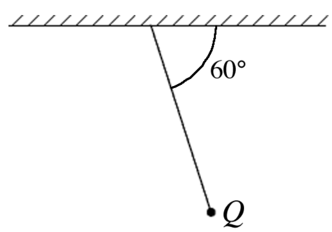
23. A small sphere with a mass of 441 g is moving upward along the vertical $+y$-axis when it encounters an electric field of 5.00 N/C $\hat{i}$. If, due to this field, the sphere suddenly acquires a horizontal acceleration of 13.0 m/s$^2$ $\hat{i}$, what is the charge that it carries?

A) 1150 C B) –1150 C C) 1.15 C D) –1.15 C

24. What is the minimum magnitude of an electric field that balances the weight of a plastic sphere of mass 6.4 g that has been charged to –3.0 nC?

A) $2.4 \times 10^{6}$ N/C B) $6.4 \times 10^{6}$ N/C C) $4.5 \times 10^{6}$ N/C D) $2.1 \times 10^{7}$ N/C

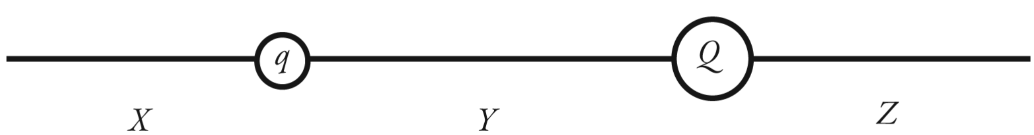
25. A point charge $Q$ of mass 8.50 g hangs from the horizontal ceiling by a light 25.0-cm thread. When a horizontal electric field of magnitude 1750 N/C is turned on, the charge hangs away from the vertical as shown in the figure. The magnitude of $Q$ is closest to




A) 3.0 $\mu$C. B) 3.5 $\mu$C. C) 47.6 $\mu$C. D) 27.5 $\mu$C. E) 55.0 $\mu$C.

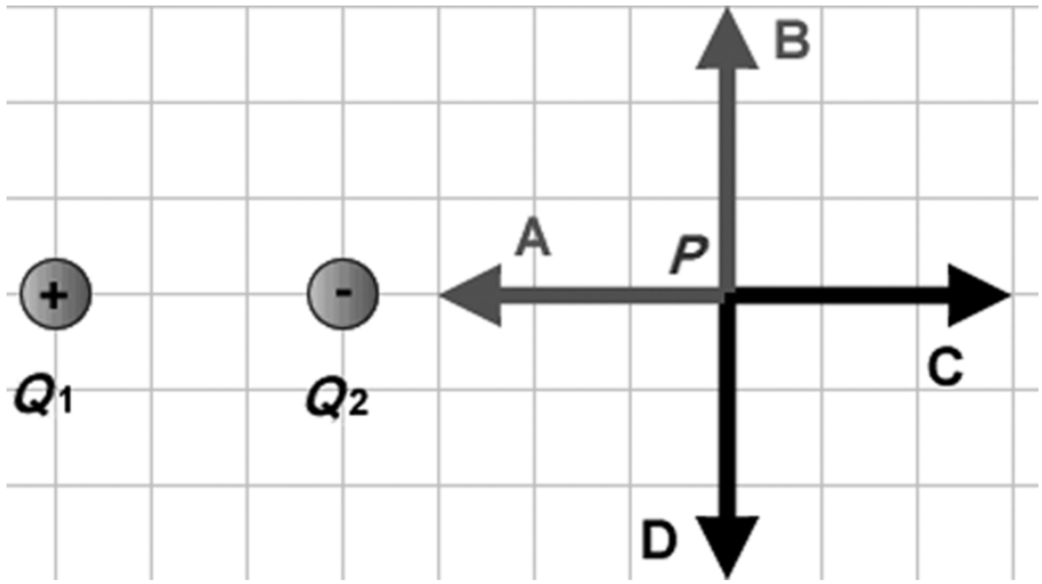
26. CHAPTER 26 STARTS HERE

The figure shows two unequal point charges, $q$ and $Q$, of opposite sign. Charge $Q$ has greater magnitude than charge $q$. In which of the regions $X$, $Y$, $Z$ will there be a point at which the net electric field due to these two charges is zero?




A) only regions $X$ and $Z$
B) only region $Z$
C) only region $Y$
D) only region $X$
E) all three regions

27. Two point charges $Q_1$ and $Q_2$ of equal magnitudes and opposite signs are positioned as shown in the figure. Which of the arrows best represents the net electric field at point $P$ due to these two charges?




A) A
B) B
C) C
D) D
E) The field is equal to zero at point $P$.

28. Four equal negative point charges are located at the corners of a square, their positions in the $xy$–plane being (1, 1), (–1, 1), (–1, –1), (1, –1). The electric field on the $x$–axis at (1, 0) points in the same direction as

A) $\hat{i}$. B) $\hat{j}$. C) $\hat{k}$. D) $-\hat{j}$. E) $-\hat{i}$

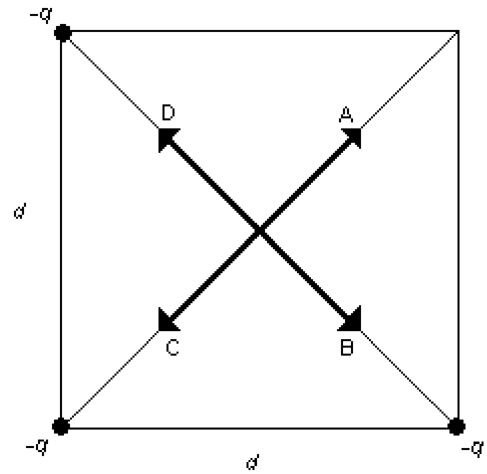
29. Two large, flat, horizontally oriented plates are parallel to each other, a distance $d$ apart. Half way between the two plates the electric field has magnitude $E$. If the separation of the plates is reduced to $d/2$ what is the magnitude of the electric field half way between the plates?

A) $4E$ B) $E$ C) 0 D) $E/2$ E) $2E$

30. Two very large parallel sheets a distance $d$ apart have their centers directly opposite each other. The sheets carry equal but opposite uniform surface charge densities. A point charge that is placed near the middle of the sheets a distance $d/2$ from each of them feels an electrical force $F$ due to the sheets. If this charge is now moved closer to one of the sheets so that it is a distance $d/4$ from that sheet, what force will feel?

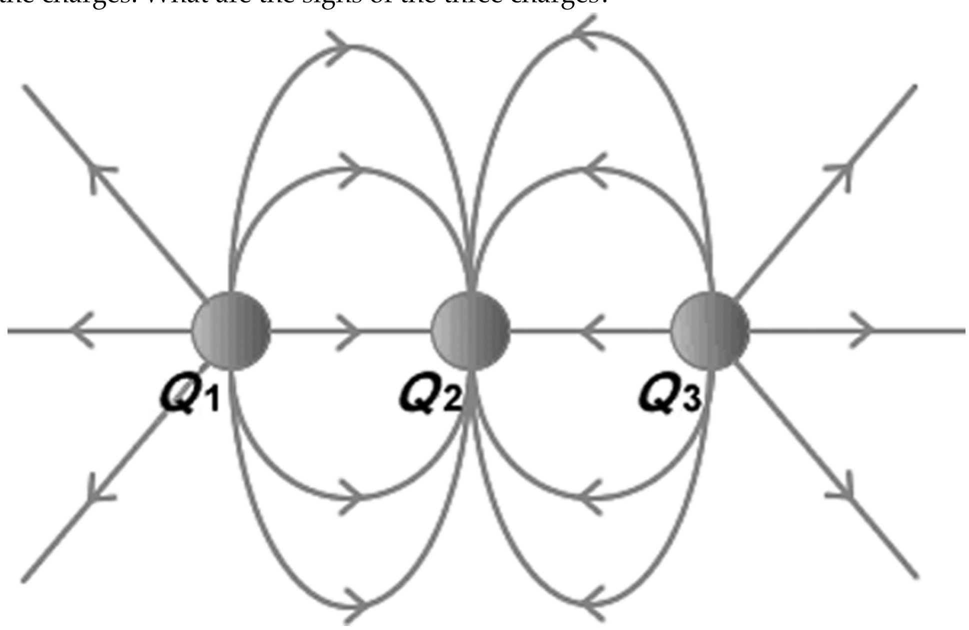
A) $2F$ B) $F/4$ C) $4F$ D) $F/2$ E) $F$

31. Three equal negative point charges are placed at three of the corners of a square of side $d$ as shown in the figure. Which of the arrows represents the direction of the net electric field at the center of the square?



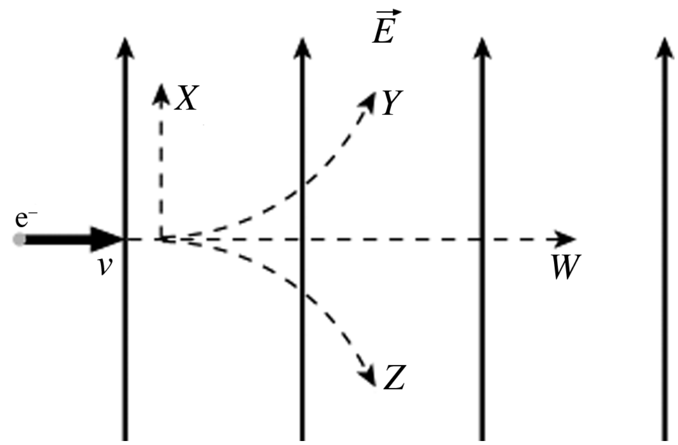

A) A
B) B
C) C
D) D
E) The field is equal to zero at point $P$.

32. The figure shows three electric charges labeled $Q_1, Q_2, Q_3$, and some electric field lines in the region surrounding the charges. What are the signs of the three charges?




A) $Q_1$ is positive, $Q_2$ is positive, $Q_3$ is negative.
B) $Q_1$ is positive, $Q_2$ is negative, $Q_3$ is positive.
C) $Q_1$ is negative, $Q_2$ is positive, $Q_3$ is negative.
D) All three charges are negative.
E) All three charges are positive.

33. An electron is initially moving to the right when it enters a uniform electric field directed upwards. Which trajectory shown below will the electron follow?

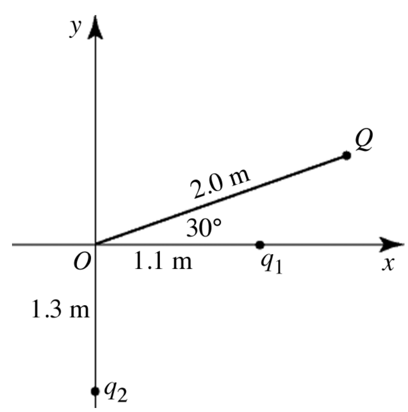



A) trajectory $Y$ B) trajectory $Z$ C) trajectory $W$ D) trajectory $X$

34. Two point charges of +20.0 μC and −8.00 μC are separated by a distance of 20.0 cm. What is the magnitude of electric field due to these charges at a point midway between them? ($k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9$ N • m$^2$/C$^2$)

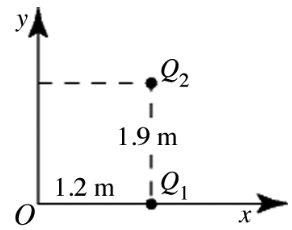
A) $25.2 \times 10^6$ N/C directed toward the positive charge
B) $25.2 \times 10^5$ N/C directed toward the negative charge
C) $25.2 \times 10^4$ N/C directed toward the negative charge
D) $25.2 \times 10^6$ N/C directed toward the negative charge
E) $25.2 \times 10^5$ N/C directed toward the positive charge

35. A point charge $Q$ = −500 nC and two unknown point charges, $q_1$ and $q_2$, are placed as shown in the figure. The electric field at the origin $O$, due to charges $Q$, $q_1$ and $q_2$, is equal to zero. The charge $q_1$ is closest to




A) 150 nC. B) 130 nC. C) 76 nC. D) −76 nC. E) −130 nC.

36. Two point charges, $Q_1 = -1.0\ \mu C$ and $Q_2 = +4.0\ \mu C$, are placed as shown in the figure. ($k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9\ N \cdot m^2/C^2$) The $y$ component of the electric field, at the origin $O$, is closest to




A) $6.0 \times 10^{-3}$ N/C.
B) $-6.0 \times 10^{-3}$ N/C.
C) $7.1 \times 10^{-3}$ N/C.
D) $-3.8 \times 10^{-3}$ N/C.
E) $3.8 \times 10^{-3}$ N/C.

37. A 3.0-$\mu$C positive point charge is located at the origin and a 2.0 $\mu$C positive point charge is located at $x = 0.00$ m, $y = 1.0$ m. Find the coordinates of the point where the net electric field strength due to these charges is zero.
A) $x = 0.00$ m, $y = 1.5$ m
B) $x = 0.00$ m, $y = 0.55$ m
C) $x = 0.00$ m, $y = 0.67$ m
D) $x = 0.00$ m, $y = 0.60$ m

38. A very long wire carries a uniform linear charge density of 7.0 nC/m. What is the electric field strength 16.0 m from the center of the wire at a point on the wire's perpendicular bisector? ($\varepsilon_0 = 8.85 \times 10^{-12}\ C^2/N \cdot m^2$)
A) 0.031 N/C
B) 7.9 N/C
C) 0.49 N/C
D) 3.9 N/C

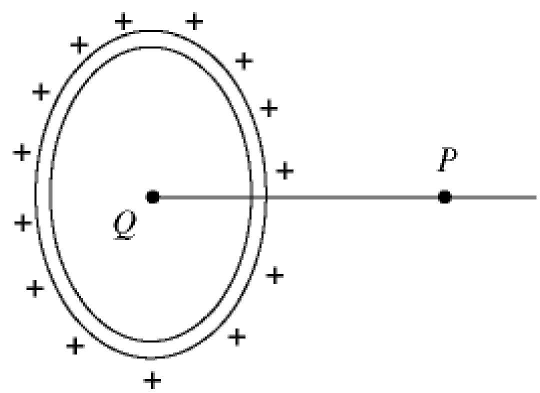
39. At a distance of 4.3 cm from the center of a very long uniformly charged wire, the electric field has magnitude 2000 N/C and is directed toward the wire. What is the charge on a 1.0 cm length of wire near the center? ($\varepsilon_0 = 8.85 \times 10^{-12}\ C^2/N \cdot m^2$)
A) −0.048 nC
B) −0.056 nC
C) −0.044 nC
D) −0.052 nC

40. A long, thin rod parallel to the $y$-axis is located at $x = -1.0$ cm and carries a uniform linear charge density of +1.0 nC/m. A second long, thin rod parallel to the $z$-axis is located at $x = +1.0$ cm and carries a uniform linear charge density of −1.0 nC/m. What is the net electric field due to these rods at the origin? ($\varepsilon_0 = 8.85 \times 10^{-12}\ C^2/N \cdot m^2$)
A) $(-3.6 \times 10^3\ N/C)\hat{i}$
B) $(3.6 \times 10^3\ N/C)\hat{i}$
C) $(1.8 \times 10^3\ N/C)\hat{j}$
D) $(-1.8 \times 10^3\ N/C)\hat{k}$
E) zero

41. A thin, circular disk of radius 30.0 cm is oriented in the $yz$–plane with its center at the origin. The disk carries a total charge of +3.00 μC distributed uniformly over its surface. Calculate the magnitude of the electric field due to the disk at the point $x$ = 15.0 cm along the $x$–axis. ($\varepsilon_0 = 8.85 \times 10^{-12}\ \mathrm{C^2/N \cdot m^2}$)

A) $1.99 \times 10^5$ N/C
B) $9.95 \times 10^5$ N/C
C) $2.49 \times 10^5$ N/C
D) $3.31 \times 10^5$ N/C
E) $4.98 \times 10^5$ N/C

42. In the figure, a ring 0.71 m in radius carries a charge of + 580 nC uniformly distributed over it. A point charge $Q$ is placed at the center of the ring. The electric field is equal to zero at field point $P$, which is on the axis of the ring, and 0.73 m from its center. ($\varepsilon_0 = 8.85 \times 10^{-12}\ \mathrm{C^2/N \cdot m^2}$) The point charge $Q$ is closest to




A) –210 B) –300 C) 300 D) –420 E) 210

43. Two very large, flat plates are parallel to each other. Plate $A$, located at $y$ = 1.0 cm, is along the $xz$–plane and carries a uniform surface charge density –1.00 $\mu\mathrm{C/m^2}$. Plate B is located at $y$ = –1.0 cm and carries a uniform surface charge density +2.00 $\mu\mathrm{C/m^2}$. What is the electric field vector at the point having $x, y, z$ coordinates (–0.50 cm, 0.00 cm, 0.00 cm)? ($\varepsilon_0 = 8.85 \times 10^{-12}\ \mathrm{C^2/N \cdot m^2}$)

A) $(-2.83 \times 10^5\ \mathrm{N/C})\hat{j}$
B) $(+1.69 \times 10^5\ \mathrm{N/C})\hat{j}$
C) $(+1.13 \times 10^5\ \mathrm{N/C})\hat{i}$
D) $(+1.19 \times 10^5\ \mathrm{N/C})\hat{j}$
E) $(-1.19 \times 10^5\ \mathrm{N/C})\hat{j}$

44. An electric field is set up between two parallel plates, each of area 2.0 $m^2$, by putting 1.0 μC of charge on one plate and –1.0 μC of charge on the other. The plates are separated by 4.0 mm with their centers opposite each other, and the charges are distributed uniformly over the surface of the plates. What is the magnitude of the electric field between the plates at a distance of 1.0 mm from the positive plate, but not near the edges of the plates? ($\varepsilon_0 = 8.85 \times 10^{-12}\ C^2/N \cdot m^2$)

A) 0.00 N/C
B) $3.1 \times 10^4$ N/C
C) $5.6 \times 10^4$ N/C
D) $4.2 \times 10^4$ N/C
E) $1.4 \times 10^4$ N/C

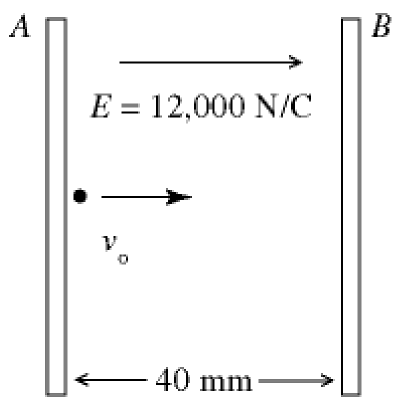
45. Two flat 4.0 cm × 4.0 cm electrodes carrying equal but opposite charges are spaced 2.0 mm apart with their midpoints opposite each other. Between the electrodes but not near their edges, the electric field strength is $2.5 \times 10^6$ N/C. What is the magnitude of the charge on each electrode? ($\varepsilon_0 = 8.85 \times 10^{-12}\ C^2/N \cdot m^2$)

A) 16 nC B) 18 nC C) 30 nC D) 35 nC

46. The electric field strength in the space between two closely spaced parallel disks is $1.0 \times 10^5$ N/C. This field is the result of transferring $3.9 \times 10^9$ electrons from one disk to the other. What is the diameter of the disks? ($e = 1.60 \times 10^{-19}$ C, $\varepsilon_0 = 8.85 \times 10^{-12}\ C^2/N \cdot m^2$)

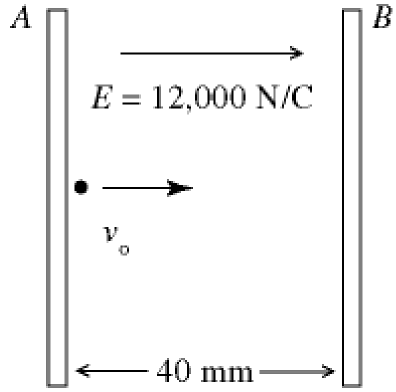
A) 1.5 cm B) 3.0 cm C) 6.0 cm D) 4.5 cm

47. A pair of charged conducting plates produces a uniform field of 12,000 N/C, directed to the right, between the plates. The separation of the plates is 40 mm. An electron is projected from plate $A$, directly toward plate $B$, with an initial velocity of $v_0 = 2.0 \times 10^7$ m/s, as shown in the figure. ($e = 1.60 \times 10^{-19}$ C, $\varepsilon_0 = 8.85 \times 10^{-12}\ C^2/N \cdot m^2$, $m_{el} = 9.11 \times 10^{-31}$ kg) The velocity of the electron as it strikes plate $B$ is closest to




A) $1.8 \times 10^7$ m/s.
B) $2.4 \times 10^7$ m/s.
C) $1.5 \times 10^7$ m/s.
D) $2.1 \times 10^7$ m/s.
E) $1.2 \times 10^7$ m/s.

48. A pair of charged conducting plates produces a uniform field of 12,000 N/C, directed to the right, between the plates. The separation of the plates is 40 mm. An electron is projected from plate $A$, directly toward plate $B$, with an initial velocity of $v_0 = 1.0 \times 10^7$ m/s, as shown in the figure. ($e = 1.60 \times 10^{-19}$ C, $\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N \cdot m^2$, $m_{el} = 9.11 \times 10^{-31}$ kg) The distance of closest approach of the electron to plate $B$ is nearest to




A) 20 mm. B) 22 mm. C) 24 mm. D) 16 mm. E) 18 mm.

49. A dipole with a positive charge of 2.0 μC and a negative charge of –2.0 μC is centered at the origin and oriented along the $x$–axis with the positive charge located to the right of the origin. The charge separation is 0.0010 m. Find the electric field due to this dipole at the point $x = 4.0$ m, $y = 0.0$ m. ($k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9$ N $\cdot$ $m^2/C^2$)

A) $-0.56\,\hat{i}$ N/C B) $-0.28\,\hat{i}$ N/C C) $0.28\,\hat{i}$ N/C D) $0.56\,\hat{i}$ N/C

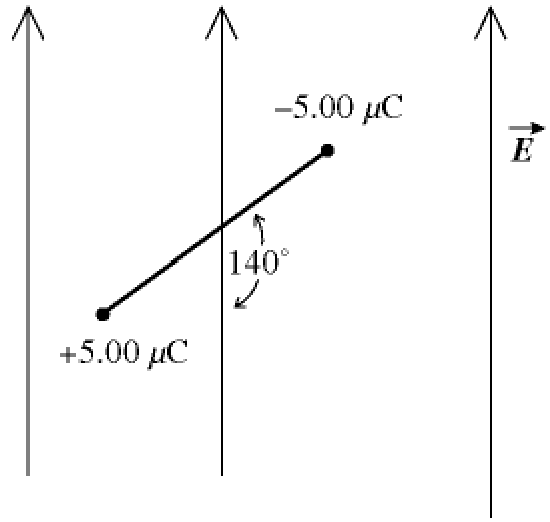
50. An electric dipole is made of two charges of equal magnitudes and opposite signs. The positive charge, $q$ = 1.0 μC, is located at the point $(x, y, z)$ = (0.00 cm, 1.0 cm, 0.00 cm), while the negative charge is located at the point $(x, y, z)$ = (0.00 cm, –1.0 cm, 0.00 cm). How much work will be done by an electric field $\vec{E} = (3.0 \times 10^6$ N/C$)\hat{i}$ to bring the dipole to its stable equilibrium position?

A) 0.060 J B) 0.12 J C) 0.00 J D) 0.030 J E) 0.020 J

51. An initially–stationary electric dipole of dipole moment $\vec{p} = (5.00 \times 10^{-10}$ C $\cdot$ m$)\hat{i}$ placed in an electric field $\vec{E} = (2.00 \times 10^6$ N/C$)\hat{i} + (2.00 \times 10^6$ N/C$)\hat{j}$. What is the magnitude of the maximum torque that the electric field exerts on the dipole?

A) $1.40 \times 10^{-3}$ N $\cdot$ m
B) $2.80 \times 10^{-3}$ N $\cdot$ m
C) $2.00 \times 10^{-3}$ N $\cdot$ m
D) $1.00 \times 10^{-3}$ N $\cdot$ m
E) 0.00 N $\cdot$ m

52. An electric dipole consists of charges ±5.00 $\mu$C separated by 1.20 mm. It is placed in a vertical electric field of magnitude 525 N/C oriented as shown in the figure. The magnitude of the net torque this field exerts on the dipole is closest to




A) $3.15 \times 10^{-6}$ N • m.
B) $1.21 \times 10^{-6}$ N • m.
C) $2.41 \times 10^{-6}$ N • m.
D) $2.02 \times 10^{-6}$ N • m.
E) $1.01 \times 10^{-6}$ N • m.

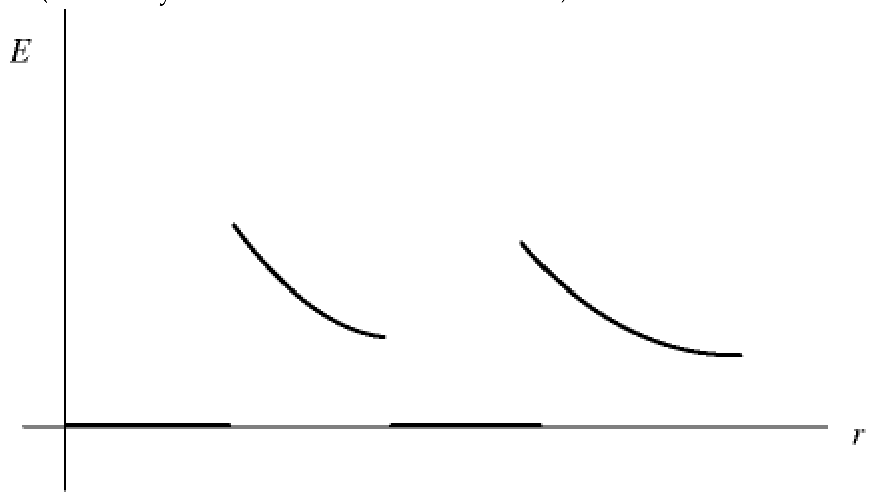
53. CHAPTER 27 STARTS HERE

If the electric flux through a closed surface is zero, the electric field at points on that surface must be zero.
A) True
B) False

54. Which of the following statements about Gauss's law are correct? (There may be more than one correct choice.)
A) If a Gaussian surface is completely inside an electrostatic conductor, the electric field must always be zero at all points on that surface.
B) The electric flux passing through a Gaussian surface depends only on the amount of charge inside that surface, not on its size or shape.
C) Gauss's law is valid only for symmetric charge distributions, such as spheres and cylinders.
D) If there is no charge inside of a Gaussian surface, the electric field must be zero at points of that surface.
E) Only charge enclosed within a Gaussian surface can produce an electric field at points on that surface.

55. Consider a spherical Gaussian surface of radius $R$ centered at the origin. A charge $Q$ is placed inside the sphere. To maximize the magnitude of the flux of the electric field through the Gaussian surface, the charge should be located
A) at $x = 0, y = 0, z = R/2$.
B) at the origin.
C) at $x = 0, y = R/2, z = 0$.
D) at $x = R/2, y = 0, z = 0$.
E) The charge can be located anywhere, since flux does not depend on the position of the charge as long as it is inside the sphere.

56. The graph in the figure shows the electric field strength (*not* the field lines) as a function of distance from the center for a pair of concentric uniformly charged spheres. Which of the following situations could the graph plausibly represent? (There may be more than one correct choice.)




A) a solid nonconducting sphere, uniformly charged throughout its volume, inside of a positively charged conducting sphere
B) a positively charged nonconducting thin–walled spherical shell inside of another positively charged nonconducting thin–walled spherical shell
C) a positively charged conducting sphere within an uncharged conducting sphere
D) a positively charged nonconducting thin–walled spherical shell inside of a positively charged conducting sphere
E) a positively charged conducting sphere within another positively charged conducting sphere

57. Two long straight parallel lines, #1 and #2, carry uniform positive linear charge densities. The charge density on line #2 is twice as great as the charge density on line #1. The locus of points where the electric field due to these lines is zero is
A) along a line perpendicular to lines #1 and #2.
B) along a line between the lines closer to line #1 than line #2.
C) along a line between the lines closer to line #2 than line #1.
D) at a point midway between the lines.

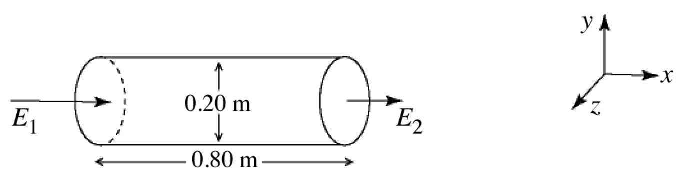
58. At a distance $D$ from a very long (essentially infinite) uniform line of charge, the electric field strength is 1000 N/C. At what distance from the line will the field strength to be 2000 N/C?
A) $D/2$ B) $D/\sqrt{2}$ C) $D/4$ D) $2D$ E) $\sqrt{2}D$

59. A charge $Q$ is uniformly spread over one surface of a very large nonconducting square elastic sheet having sides of length $d$. At a point $P$ that is 1.25 cm outside the sheet, the magnitude of the electric field due to the sheet is $E$. If the sheet is now stretched so that its sides have length $2d$, what is the magnitude of the electric field at $P$?
A) $E/4$ B) $E$ C) $E/2$ D) $4E$ E) $2E$

60. An uncharged conductor has a hollow cavity inside of it. Within this cavity there is a charge of +10 $\mu$C that does not touch the conductor. There are no other charges in the vicinity. Which statement about this conductor is true? (There may be more than one correct choice.)
   A) The inner and outer surfaces of the conductor each contain charges of –5 $\mu$C.
   B) The inner surface of the conductor carries a charge of –10 $\mu$C and its outer surface carries no excess charge.
   C) Both surfaces of the conductor carry no excess charge because the conductor is uncharged.
   D) The net electric field within the material of the conductor points away from the +10 $\mu$C charge.
   E) The outer surface of the conductor contains +10 $\mu$C of charge and the inner surface contains –10 $\mu$C.

61. Under electrostatic conditions, the electric field just outside the surface of any charged conductor
   A) is always zero because the electric field is zero inside conductors.
   B) is always parallel to the surface.
   C) is always perpendicular to the surface of the conductor.
   D) is perpendicular to the surface of the conductor only if it is a sphere, a cylinder, or a flat sheet.
   E) can have nonzero components perpendicular to and parallel to the surface of the conductor.

62. A nonuniform electric field is directed along the $x$–axis at all points in space. This magnitude of the field varies with $x$, but not with respect to $y$ or $z$. The axis of a cylindrical surface, 0.80 m long and 0.20 m in diameter, is aligned parallel to the $x$–axis, as shown in the figure. The electric fields $E_1$ and $E_2$, at the ends of the cylindrical surface, have magnitudes of 6000 N/C and 1000 N/C respectively, and are directed as shown. What is the net electric flux passing through the cylindrical surface?




   A) –160 N • m$^2$/C
   B) +350 N • m$^2$/C
   C) 0.00 N • m$^2$/C
   D) –350 N • m$^2$/C
   E) +160 N • m$^2$/C

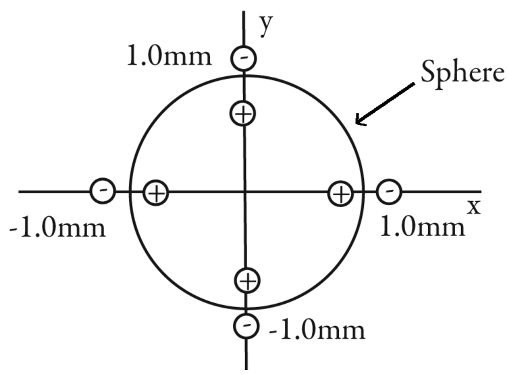
63. If a rectangular area is rotated in a uniform electric field from the position where the maximum electric flux goes through it to an orientation where only half the flux goes through it, what has been the angle of rotation?
   A) 30°  B) 26.6°  C) 90°  D) 45°  E) 60°

64. A charge $q$ = 2.00 μC is placed at the origin in a region where there is already a uniform electric field $\vec{E}$ = (100 N/C)$\hat{i}$. Calculate the flux of the net electric field through a Gaussian sphere of radius $R$ = 10.0 cm centered at the origin. ($\varepsilon_0$ = 8.85 × $10^{-12}$ C$^2$/N • m$^2$)
   A) 5.52 × $10^5$ N • m$^2$/C
   B) 1.13 × $10^5$ N • m$^2$/C
   C) zero
   D) 2.26 × $10^5$ N • m$^2$/C

65. A charge of $1.0 \times 10^{-6}$ μC is located inside a sphere, 1.25 cm from its center. What is the electric flux through the sphere due to this charge? ($\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N \cdot m^2$)

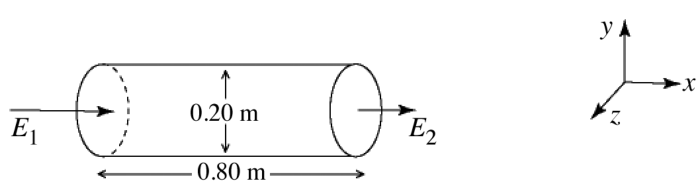
A) $8.9$ $N \cdot m^2/C$
B) $0.11$ $N \cdot m^2/C$
C) $0.028\pi$ $N \cdot m^2/C$
D) It cannot be determined without knowing the radius of the sphere.

66. Four dipoles, each consisting of a +10-$\mu$C charge and a -10-$\mu$C charge, are located in the $xy$-plane with their centers 1.0 mm from the origin, as shown. A sphere passes through the dipoles, as shown in the figure. What is the electric flux through the sphere due to these dipoles? ($\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N \cdot m^2$)




A) $0.00$ $N \cdot m^2/C$
B) $11 \times 10^5$ $N \cdot m^2/C$
C) $4.5 \times 10^6$ $N \cdot m^2/C$
D) $9.0 \times 10^6$ $N \cdot m^2/C$

67. A nonuniform electric field is directed along the $x$-axis at all points in space. This magnitude of the field varies with $x$, but not with respect to $y$ or $z$. The axis of a cylindrical surface, 0.80 m long and 0.20 m in diameter, is aligned parallel to the $x$-axis, as shown in the figure. The electric fields $E_1$ and $E_2$, at the ends of the cylindrical surface, have magnitudes of 9000 N/C and 5000 N/C respectively, and are directed as shown. ($\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N \cdot m^2$) The charge enclosed by the cylindrical surface is closest to




A) 4.8 nC.
B) -1.1 nC.
C) -4.8 nC.
D) 1.1 nC.
E) -2.4 nC.

68. A solid nonconducting sphere of radius $R$ carries a uniform charge density throughout its volume. At a radial distance $r_1 = R/4$ from the center, the electric field has a magnitude $E_0$. What is the magnitude of the electric field at a radial distance $r_2 = 2R$?

A) zero
B) $E_0$
C) $2E_0$
D) $E_0/2$
E) $E_0/4$

69. A solid nonconducting sphere of radius $R$ carries a charge $Q$ distributed uniformly throughout its volume. At a certain distance $r_1$ ($r_1 < R$) from the center of the sphere, the electric field has magnitude $E$. If the same charge $Q$ were distributed uniformly throughout a sphere of radius $2R$, the magnitude of the electric field at the same distance $r_1$ from the center would be equal to

A) $E/8$. B) $8E$. C) $E/2$. D) $E$. E) $2E$.

70. A spherical, non-conducting shell of inner radius $r_1 = 10$ cm and outer radius $r_2 = 15$ cm carries a total charge $Q = 15$ μC distributed uniformly throughout the volume of the shell. What is the magnitude of the electric field at a distance $r = 12$ cm from the center of the shell? ($k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9$ N • m$^2$/C$^2$)

A) $2.87 \times 10^6$ N/C
B) zero
C) $5.75 \times 10^6$ N/C
D) $5.75 \times 10^3$ N/C
E) $2.87 \times 10^3$ N/C

71. A non-conducting sphere of radius $R = 7.0$ cm carries a charge $Q = 4.0$ mC distributed uniformly throughout its volume. At what distance, measured from the center of the sphere, does the electric field reach a value equal to half its maximum value?

A) 9.9 cm only
B) 3.5 cm and 9.9 cm
C) 3.5 cm and 4.9 cm
D) 3.5 cm only
E) 4.9 cm only

72. Electric charge is uniformly distributed inside a nonconducting sphere of radius 0.30 m. The electric field at a point $P$, which is 0.50 m from the center of the sphere, is 15,000 N/C and is directed radially outward. At what distance from the center of the sphere does the electric field have the same magnitude as it has at $P$?

A) 0.11 m
B) 0.17 m
C) 0.13 m
D) 0.15 m
E) at no other point

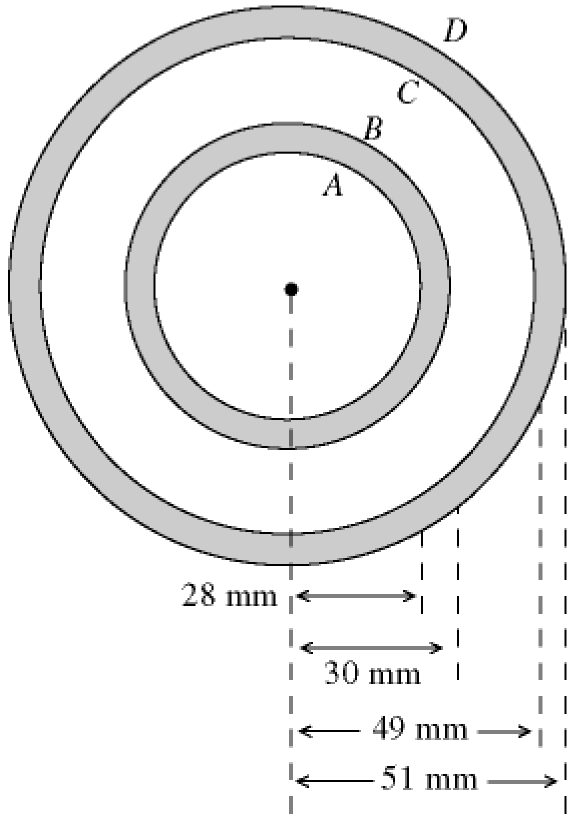
73. Electric charge is uniformly distributed inside a nonconducting sphere of radius 0.30 m. The electric field at a point $P$, which is 0.50 m from the center of the sphere, is 15,000 N/C and is directed radially outward. What is the maximum magnitude of the electric field due to this sphere?

A) 36,000 N/C B) 48,000 N/C C) 30,000 N/C D) 25,000 N/C E) 42,000 N/C

74. An infinitely long nonconducting cylinder of radius $R = 2.00$ cm carries a uniform volume charge density of 18.0 μC/ m$^3$. Calculate the electric field at distance $r = 1.00$ cm from the axis of the cylinder. ($\varepsilon_0 = 8.85 \times 10^{-12}$ C$^2$/N • m$^2$)

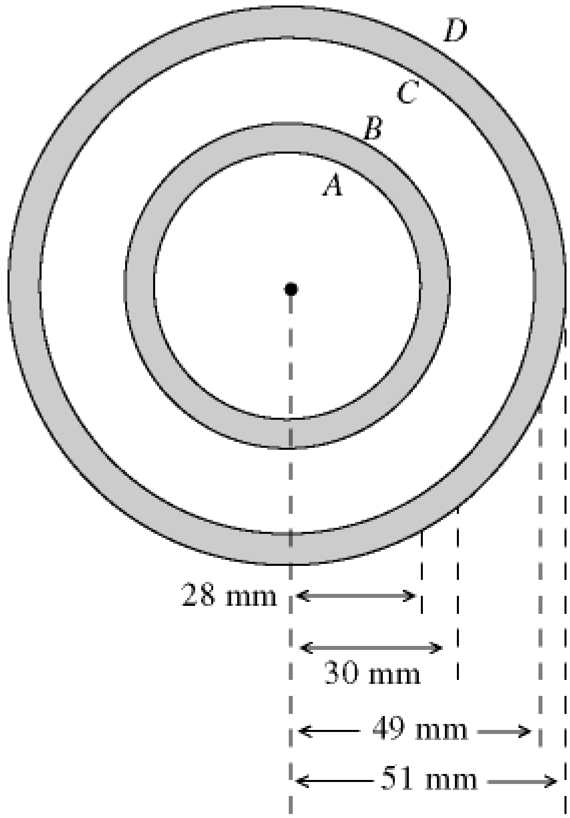
A) $2.00 \times 10^3$ N/C
B) $5.10 \times 10^3$ N/C
C) $10.2 \times 10^3$ N/C
D) zero
E) $2.50 \times 10^3$ N/C

75. The cross section of a long coaxial cable is shown in the figure, with radii as given. The linear charge density on the inner conductor is $-30$ nC/m and the linear charge density on the outer conductor is $-70$ nC/m. The inner and outer cylindrical surfaces are respectively denoted by $A$, $B$, $C$, and $D$, as shown.
($\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N \cdot m^2$) The radial component of the electric field at a point that 34 mm from the axis is closest to




A) +37,000 N/C.
B) –37,000 N/C.
C) –16,000 N/C.
D) +16,000 N/C.
E) zero

76. The cross section of a long coaxial cable is shown in the figure, with radii as given. The linear charge density on the inner conductor is –40 nC/m and the linear charge density on the outer conductor is –50 nC/m. The inner and outer cylindrical surfaces are respectively denoted by $A$, $B$, $C$, and $D$, as shown. ($\varepsilon_0 = 8.85 \times 10^{-12}\ \mathrm{C^2/N \cdot m^2}$) The magnitude of the electric field at a point that is 94 mm from the axis is closest to




A) 13,000 N/C.
B) 15,000 N/C.
C) 9600 N/C.
D) 17,000 N/C.
E) 11,000 N/C.

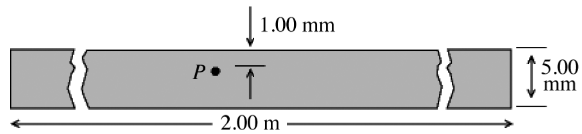
77. A very large sheet of a conductor carries a uniform charge density of 4.00 $\mathrm{pC/mm^2}$ on its surfaces. What is the electric field strength 3.00 mm outside the surface of the conductor? ($\varepsilon_0 = 8.85 \times 10^{-12}\ \mathrm{C^2/N \cdot m^2}$)

A) $2.26 \times 10^5$ N/C
B) 0.452 N/C
C) 0.226 N/C
D) $4.52 \times 10^5$ N/C
E) $9.04 \times 10^5$ N/C

78. A huge (essentially infinite) horizontal nonconducting sheet 10.0 cm thick has charge uniformly spread over both faces. The upper face carries +95.0 $nC/m^2$ while the lower face carries –25.0 $nC/m^2$. What is the magnitude of the electric field at a point within the sheet 2.00 cm below the upper face? ($\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N \cdot m^2$)

A) $7.91 \times 10^3$ N/C
B) $6.78 \times 10^3$ N/C
C) $3.95 \times 10^3$ N/C
D) 0.00 N/C
E) $1.36 \times 10^4$ N/C

79. As shown in the figure, a square insulating slab 5.0 mm thick measuring 2.0 m × 2.0 m has a charge of $8.0 \times 10^{-11}$ C distributed uniformly throughout its volume. Use Gauss's law to determine the electric field at point $P$, which is located within the slab beneath its center, 1.0 mm from one of the faces. ($\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N \cdot m^2$)

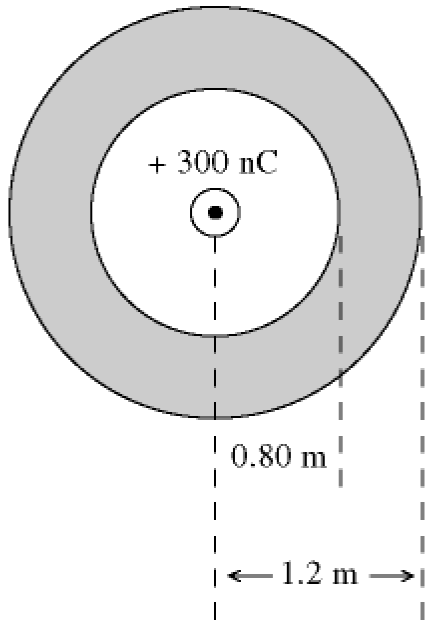



A) 57 N/C
B) 34 N/C
C) 23 N/C
D) 0.68 N/C
E) 14 N/C

80. Consider two closely spaced and oppositely charged parallel metal plates. The plates are square with sides of length $L$ and carry charges $Q$ and $-Q$ on their facing surfaces. What is the magnitude of the electric field in the region between the plates?

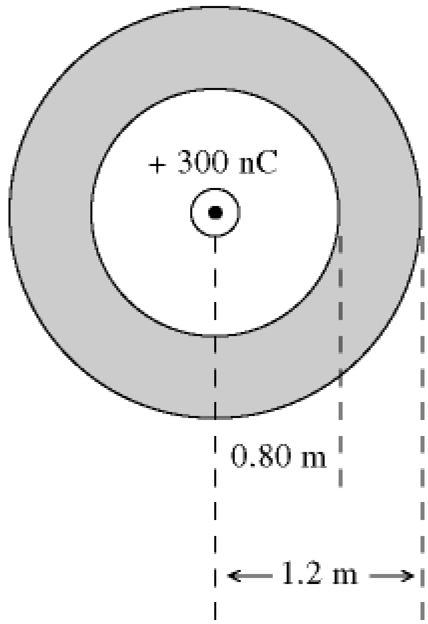
A) $E = \dfrac{4Q}{\varepsilon_0 L^2}$
B) $E = \dfrac{Q}{2\varepsilon_0 L^2}$
C) $E = \dfrac{Q}{\varepsilon_0 L^2}$
D) $E = 0$
E) $E = \dfrac{2Q}{\varepsilon_0 L^2}$

81. A hollow conducting spherical shell has radii of 0.80 m and 1.20 m, as shown in the figure. The sphere carries an excess charge of –500 nC. A point charge of +300 nC is present at the center. The surface charge density on the inner spherical surface is closest to



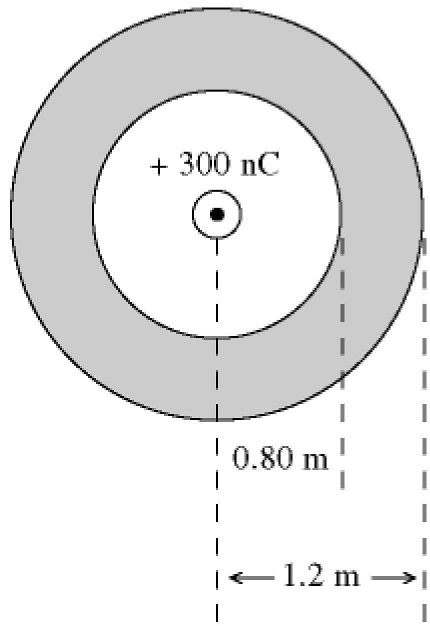

A) zero.
B) $-6.0 \times 10^{-8}$ C/ m$^2$.
C) $+4.0 \times 10^{-8}$ C/m$^2$.
D) $+6.0 \times 10^{-8}$ C/ m$^2$.
E) $-4.0 \times 10^{-8}$ C/ m$^2$.

82. A hollow conducting spherical shell has radii of 0.80 m and 1.20 m, as shown in the figure. The sphere carries a net excess charge of −500 nC. A point charge of +300 nC is present at the center. ($k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9\ \mathrm{N \cdot m^2/C}$) The radial component of the electric field at a point that is 0.60 m from the center is closest to




A) zero.
B) +5000 N/C.
C) −7500 N/C.
D) −5000 N/C.
E) +7500 N/C.

83. A hollow conducting spherical shell has radii of 0.80 m and 1.20 m, as shown in the figure. The sphere carries a net excess charge of –500 nC. A point charge of +300 nC is present at the center. ($k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9$ N • m$^2$/C) The radial component of the electric field at a point that is 1.50 m from the center is closest to




A) +1200 N/C.
B) –800 N/C.
C) +2000 N/C.
D) –1600 N/C.
E) –2000 N/C.

84. CHAPTER 28 STARTS HERE

If the electric field is zero everywhere inside a region of space, the potential must also be zero in that region.
A) True B) False

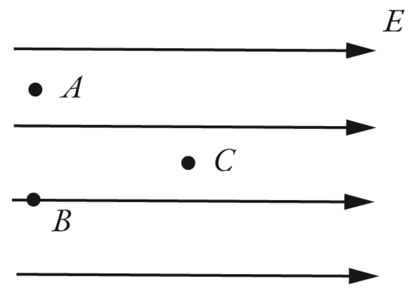
85. When the electric field is zero at a point, the potential must also be zero there.
A) True B) False

86. If the electrical potential in a region is constant, the electric field must be zero everywhere in that region.
A) True B) False

87. If the electric potential at a point in space is zero, then the electric field at that point must also be zero.
A) True B) False

88. A negative charge, if free, will tend to move
A) from low potential to high potential.
B) toward infinity.
C) in the direction of the electric field.
D) from high potential to low potential.
E) away from infinity.

89. Suppose a region of space has a uniform electric field, directed towards the right, as shown in the figure. Which statement about the electric potential is true?




A) The potential at all three locations ($A, B, C$) is the same because the field is uniform.
B) The potential at point $A$ is the highest, the potential at point $B$ is the second highest, and the potential at point $C$ is the lowest.
C) The potential at points $A$ and $B$ are equal, and the potential at point $C$ is lower than the potential at point $A$.
D) The potential at points $A$ and $B$ are equal, and the potential at point $C$ is higher than the potential at point $A$.

90. Which statements are true for an electron moving in the direction of an electric field? (There may be more than one correct choice.)
A) Its potential energy increases as its kinetic energy decreases.
B) Its electric potential energy increases as it goes from high to low potential.
C) Its kinetic energy decreases as it moves in the direction of the electric field.
D) Its electric potential energy decreases as it goes from high to low potential.
E) Its kinetic energy increases as it moves in the direction of the electric field.

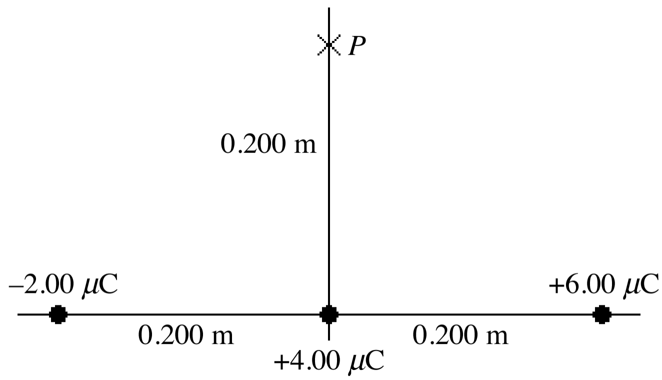
91. Suppose you have two point charges of opposite sign. As you move them farther and farther apart, the potential energy of this system relative to infinity
A) stays the same. B) decreases. C) increases.

92. Suppose you have two negative point charges. As you move them farther and farther apart, the potential energy of this system relative to infinity
A) stays the same. B) decreases. C) increases.

93. Two equal positive charges are held in place at a fixed distance. If you put a third positive charge midway between these two charges, its electrical potential energy of the system (relative to infinity) is zero because the electrical forces on the third charge due to the two fixed charges just balance each other.
A) True B) False

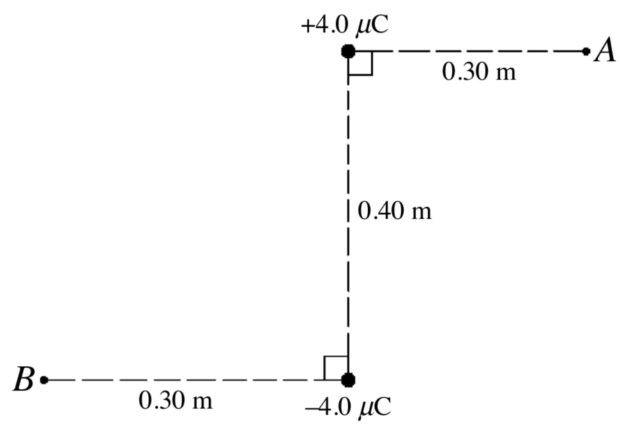
94. A negative charge is moved from point $A$ to point $B$ along an equipotential surface. Which of the following statements must be true for this case?
A) Work is required to move the negative charge from point $A$ to point $B$.
B) Work is done in moving the negative charge from point $A$ to point $B$.
C) The work done on the charge depends on the distance between $A$ and $B$.
D) No work is required to move the negative charge from point $A$ to point $B$.
E) The negative charge performs work in moving from point $A$ to point $B$.

95. Three point charges of −2.00 μC, +4.00 μC, and +6.00 μC are placed along the $x$−axis as shown in the figure. What is the electrical potential at point $P$ (relative to infinity) due to these charges? ($k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9$ N • $m^2/C^2$)




A) −154 kV B) 0 kV C) −307 kV D) +307 kV E) +154 kV

96. A +4.0 μC−point charge and a −4.0−μC point charge are placed as shown in the figure. What is the potential difference, $V_A - V_B$, between points $A$ and $B$? ($k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9$ N • $m^2/C^2$)




A) 96 kV B) 0.00 V C) 48 V D) 48 kV E) 96 V

97. Two point charges of +2.0 μC and −6.0 μC are located on the $x$−axis at $x = -1.0$ cm and $x = +2.0$ cm respectively. Where should a third charge of +3.0−μC be placed on the +$x$−axis so that the potential at the origin is equal to zero? ($k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9$ N • $m^2/C^2$)

A) $x = 4.0$ cm B) $x = 3.0$ cm C) $x = 1.0$ cm D) $x = 5.0$ cm E) $x = 2.0$ cm

98. A −7.0−μC point charge has a positively charged object in an elliptical orbit around it. If the mass of the positively charged object is 1.0 kg and the distance varies from 5.0 mm to 20.0 mm between the charges, what is the maximum electric potential difference through which the positive object moves? ($k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9$ N • $m^2/C^2$)

A) 9.4 MV B) 16 MV C) 3.2 MV D) 4.2 MV

99. A very small object carrying $-6.0\ \mu C$ of charge is attracted to a large, well-anchored, positively charged object. How much kinetic energy does the negatively charged object gain if the potential difference through which it moves is 3.0 mV? ($k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9\ N \cdot m^2/C^2$)

A) 6.0 μJ  B) 18 nJ  C) 0.50 kJ  D) 0.50 J

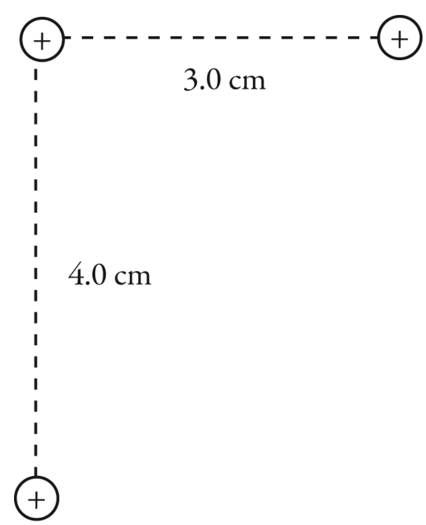
100. Two point charges of $+1.0\ \mu C$ and $-2.0\ \mu C$ are located 0.50 m apart. What is the minimum amount of work needed to move the charges apart to double the distance between them? ($k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9\ N \cdot m^2/C^2$)

A) +18 mJ  B) +36 mJ  C) −36 mJ  D) −18 mJ  E) 0 mJ

101. If an electron is accelerated from rest through a potential difference of 9.9 kV, what is its resulting speed? ($e = 1.60 \times 10^{-19}$ C, $k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9\ N \cdot m^2/C^2$, $m_{el} = 9.11 \times 10^{-31}$ kg)

A) $2.9 \times 10^7$ m/s  B) $5.9 \times 10^7$ m/s  C) $3.9 \times 10^7$ m/s  D) $4.9 \times 10^7$ m/s

102. Consider the group of three +2.4 nC point charges shown in the figure. What is the electric potential energy of this system of charges relative to infinity? ($k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9\ N \cdot m^2/C^2$)




A) $4.2 \times 10^{-6}$ J  B) $4.4 \times 10^{-6}$ J  C) $4.6 \times 10^{-6}$ J  D) $4.1 \times 10^{-6}$ J

103. An electron is released from rest at a distance of 9.00 cm from a proton. If the proton is held in place, how fast will the electron be moving when it is 3.00 cm from the proton? ($m_{el} = 9.11 \times 10^{-31}$ kg, $e = 1.60 \times 10^{-19}$ C, $k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9\ N \cdot m^2/C^2$)

A) 106 m/s
B) 75.0 m/s
C) $1.06 \times 10^3$ m/s
D) $4.64 \times 10^5$ m/s
E) 130 m/s

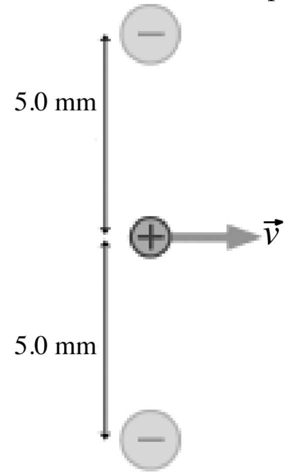
104. A $-3.0$-μC point charge and a $-9.0$-μC point charge are initially extremely far apart. How much work does it take to bring the $-3.0$-μC charge to $x = 3.0$ mm, $y = 0.00$ mm and the $-9.0$-μC charge to $x = -3.0$ mm, $y = 0.00$ mm? ($k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9\ N \cdot m^2/C^2$)

A) 40 J  B) 6.8 J  C) 81 J  D) 27 J

105. A tiny object carrying a charge of +3.00 μC and a second tiny charged object are initially very far apart. If it takes 29.0 J of work to bring them to a final configuration in which the +3.00 μC object i is at $x = 1.00$ mm, $y = 1.00$ mm, and the other charged object is at $x = 1.00$ mm, $y = 3.00$ mm, find the magnitude of the charge on the second object. ($k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9\ \mathrm{N \cdot m^2/C^2}$)

A) 4.30 μC B) 4.30 nC C) 2.15 μC D) 10.74 μC

106. The figure shows an arrangement of two −4.5 nC charges, each separated by 5.0 mm from a proton. If the two negative charges are held fixed at their locations and the proton is given an initial velocity $v$ as shown in the figure, what is the minimum initial speed $v$ that the proton needs to totally escape from the negative charges? ($k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9\ \mathrm{N \cdot m^2/C^2}$, $e = 1.60 \times 10^{-19}$ C, $m_{\text{proton}} = 1.67 \times 10^{-27}$ kg)




A) $1.4 \times 10^7$ m/s B) $3.5 \times 10^6$ m/s C) $6.8 \times 10^6$ m/s D) $1.8 \times 10^6$ m/s

107. An alpha particle is a nucleus of helium. It has twice the charge and four times the mass of the proton. When they were very far away from each other, but headed toward directly each other, a proton and an alpha particle each had an initial speed of $0.0030c$, where $c$ is the speed of light. What is their distance of closest approach? *Hint:* There are *two* conserved quantities. Make use of both of them. ($c = 3.00 \times 10^8$ m/s, $k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9\ \mathrm{N \cdot m^2/C^2}$, $e = 1.60 \times 10^{-19}$ C, $m_{\text{proton}} = 1.67 \times 10^{-27}$ kg)

A) $2.6 \times 10^{-13}$ m B) $2.9 \times 10^{-13}$ m C) $2.1 \times 10^{-13}$ m D) $3.3 \times 10^{-13}$ m

108. A sphere with radius 2.0 mm carries +1.0 μC of charge distributed uniformly throughout its volume. What is the potential difference, $V_B - V_A$, between point $B$, which is 4.0 m from the center of the sphere, and point $A$, which is 9.0 m from the center of the sphere? ($k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9\ \mathrm{N \cdot m^2/C^2}$)

A) −0.45 V B) −1200 V C) 140 V D) 1200 V

109. A conducting sphere is charged up such that the potential on its surface is 100 V (relative to infinity). If the sphere's radius were twice as large, but the charge on the sphere were the same, what would be the potential on the surface relative to infinity?

A) 200 V B) 100 V C) 25 V D) 50 V

110. A conducting sphere of radius 20.0 cm carries an excess charge of +15.0 $\mu$C, and no other charges are present. ($k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9\ \mathrm{N \cdot m^2/C^2}$) The potential (relative to infinity) due to this sphere at a point 12.0 cm from its center is closest to

A) 674 kV. B) 3380 kV. C) zero. D) 9380 kV. E) 1130 kV.

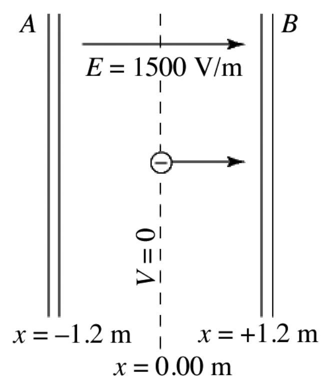
111. A conducting sphere 45 cm in diameter carries an excess of charge, and no other charges are present. You measure the potential of the surface of this sphere and find it to be 14 kV relative to infinity. ($k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9\ \mathrm{N \cdot m^2/C^2}$) The excess charge on this sphere is closest to

A) 79 nC. B) 700 nC. C) 315 nC. D) 0.35 nC. E) 350 nC.

112. Two parallel conducting plates are separated by 1.0 mm and carry equal but opposite surface charge densities. If the potential difference between them is 2.0 V, what is the magnitude of the surface charge density on each plate? ($\varepsilon_0 = 8.85 \times 10^{-12}\ \mathrm{C^2/N \cdot m^2}$)

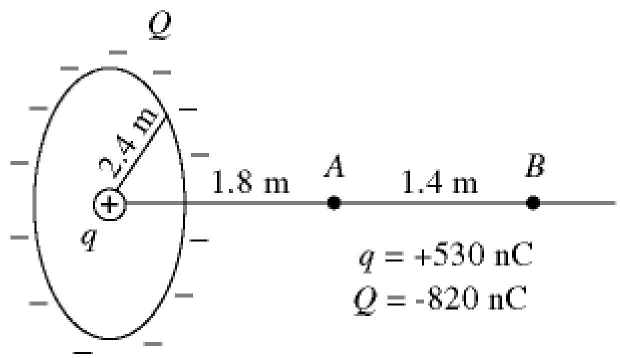
A) 18 $\mathrm{nC/m^2}$ B) 0.27 $\mathrm{mC/m^2}$ C) 0.13 $\mathrm{mC/m^2}$ D) 35 $\mathrm{nC/m^2}$

113. Two large conducting parallel plates $A$ and $B$ are separated by 2.4 m. A uniform field of 1500 V/m, in the positive $x$-direction, is produced by charges on the plates. The center plane at $x = 0.00$ m is an equipotential surface on which $V = 0$. An electron is projected from $x = 0.00$ m, with an initial velocity of $1.0 \times 10^7$ m/s perpendicular to the plates in the positive $x$-direction, as shown in the figure. What is the kinetic energy of the electron as it reaches plate $A$? ($e = 1.60 \times 10^{-19}$ C, $m_{el} = 9.11 \times 10^{-31}$ kg)



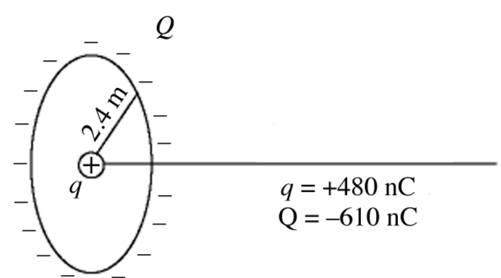

A) $+2.4 \times 10^{-16}$ J
B) $-2.4 \times 10^{-16}$ J
C) $+3.3 \times 10^{-16}$ J
D) $-3.3 \times 10^{-16}$ J
E) $-2.9 \times 10^{-16}$ J

114. A charge $Q = -820$ nC is uniformly distributed on a ring of 2.4 m radius. A point charge $q = +530$ nC is fixed at the center of the ring. Points $A$ and $B$ are located on the axis of the ring, as shown in the figure. What is the minimum work that an external force must do to transport an electron from $B$ to $A$? ($e = 1.60 \times 10^{-19}$ C, $k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9$ N $\cdot$ m$^2$/C$^2$)




A) $+8.7 \times 10^{-17}$ J
B) $+7.2 \times 10^{-18}$ J
C) $-7.2 \times 10^{-18}$ J
D) $+1.0 \times 10^{-16}$ J
E) $-8.7 \times 10^{-17}$ J

115. A charge $Q = -610$ nC is uniformly distributed on a ring of 2.4–m radius. A point charge $q = +480$ nC is fixed at the center of the ring, as shown in the figure. An electron is projected from infinity toward the ring along the axis of the ring. This electron comes to a momentary halt at a point on the axis that is 5.0 m from the center of the ring. What is the initial speed of the electron at infinity? ($e = 1.60 \times 10^{-19}$ C, $k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9$ N $\cdot$ m$^2$/C$^2$, $m_{el} = 9.11 \times 10^{-31}$ kg)

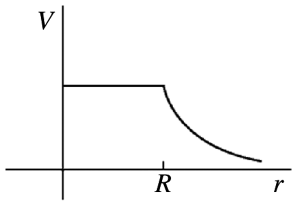



A) $4.5 \times 10^6$ m/s
B) $3.4 \times 10^6$ m/s
C) $6.6 \times 10^6$ m/s
D) $2.2 \times 10^6$ m/s
E) $1.1 \times 10^6$ m/s

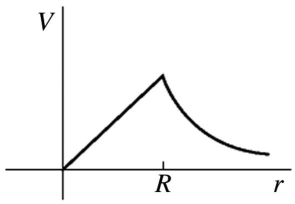
116. CHAPTER 29 STARTS HERE

A conducting sphere of radius $R$ carries an excess positive charge and is very far from any other charges. Which one of the following graphs best illustrates the potential (relative to infinity) produced by this sphere as a function of the distance $r$ from the center of the sphere?

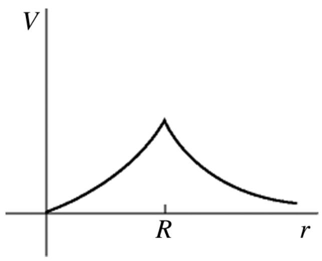
A)



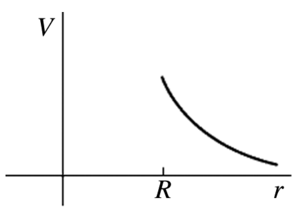

B)



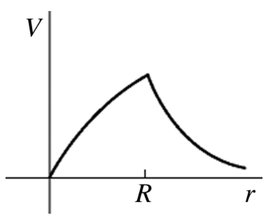

C)




D)



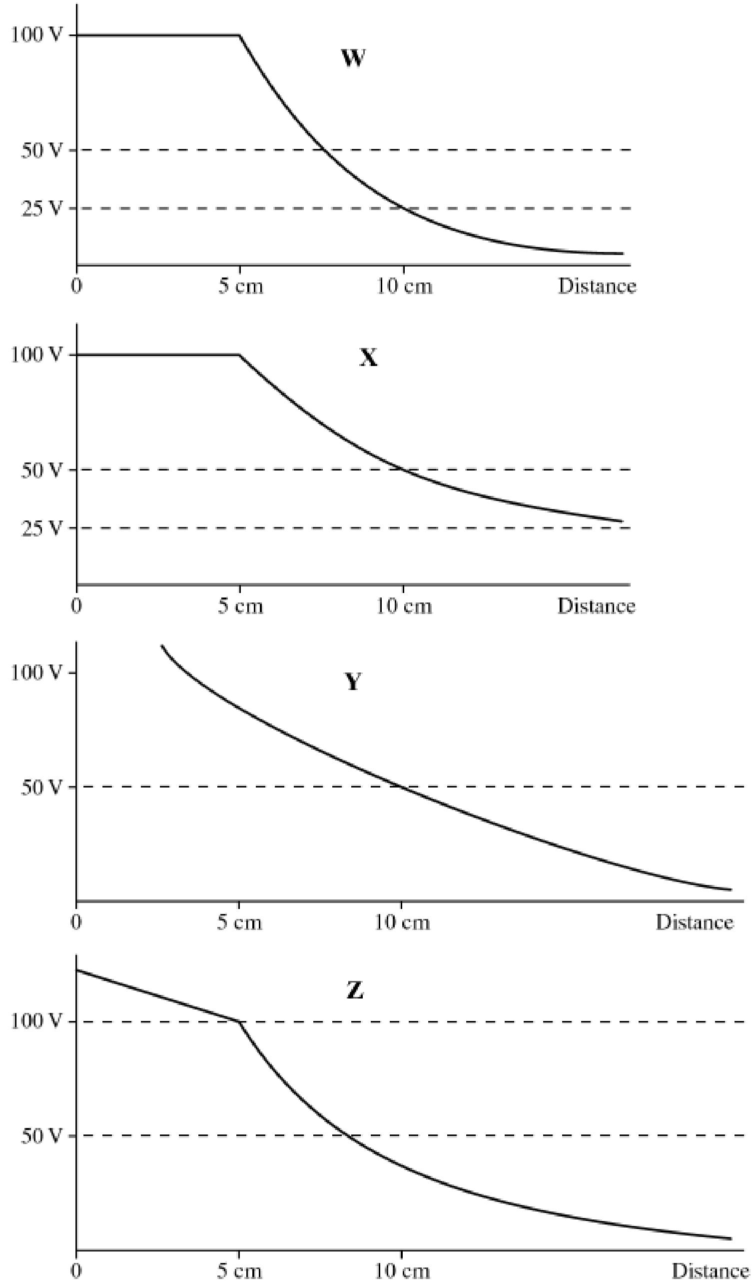

E)




117. A nonconducting sphere contains positive charge distributed uniformly throughout its volume. Which statements about the potential due to this sphere are true? All potentials are measured relative to infinity. (There may be more than one correct choice.)

A) The potential at the center of the sphere is zero.
B) The potential at the center of the sphere is the same as the potential at the surface.
C) The potential at the center is the same as the potential at infinity.
D) The potential is highest at the center of the sphere.
E) The potential at the surface is higher than the potential at the center.

118. A metallic sphere of radius 5 cm is charged such that the potential of its surface is 100 V (relative to infinity). Which of the following plots correctly shows the potential as a function of distance from the center of the sphere?

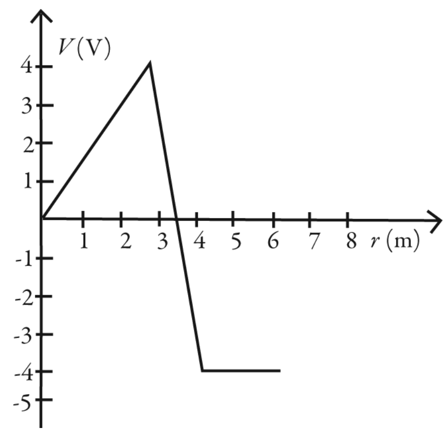



A) plot W    B) plot X    C) plot Y    D) plot Z

119. A conducting sphere contains positive charge distributed uniformly over its surface. Which statements about the potential due to this sphere are true? All potentials are measured relative to infinity. (There may be more than one correct choice.)

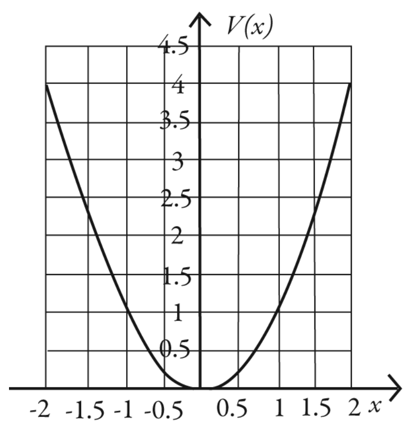
A) The potential is lowest, but not zero, at the center of the sphere.
B) The potential at the center of the sphere is the same as the potential at the surface.
C) The potential at the surface is higher than the potential at the center.
D) The potential at the center of the sphere is zero.
E) The potential at the center is the same as the potential at infinity.

120. The graph in the figure shows the variation of the electric potential $V$ (measured in volts) as a function of the radial direction $r$ (measured in meters). For which range or value of $r$ is the magnitude of the electric field the largest?



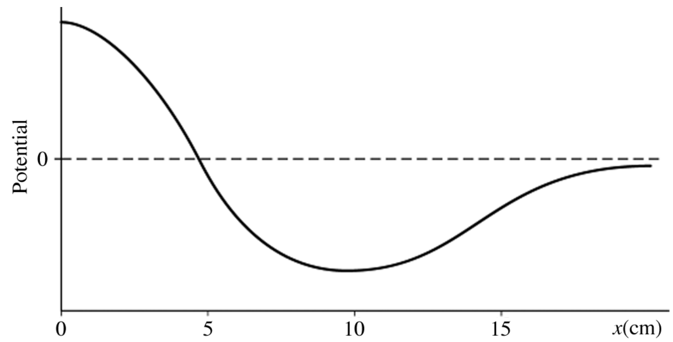

A) at $r = 4$ m
B) from $r = 0$ m to $r = 3$ m
C) at $r = 3$ m
D) from $r = 3$ m to $r = 4$ m
E) from $r = 4$ m to $r = 6$ m

121. The graph in the figure shows the variation of the electric potential $V(x)$ (in arbitrary units) as a function of the position $x$ (also in arbitrary units). Which of the choices below correctly describes the orientation of the $x$–component of the electric field along the $x$–axis?




A) $E_x$ is positive from $x = -2$ to $x = 0$, and negative from $x = 0$ to $x = 2$.
B) $E_x$ is positive from $x = -2$ to $x = 2$.
C) $E_x$ is negative from $x = -2$ to $x = 2$.
D) $E_x$ is negative from $x = -2$ to $x = 0$, and positive from $x = 0$ to $x = 2$.

122. The potential as a function of position $x$ is shown in the graph in the figure. Which statement about the electric field is true?




A) The electric field is zero at $x = 0$, its magnitude is at a maximum at $x = 15$ cm, and the field is directed to the left there.
B) The electric field is zero at $x = 0$, its magnitude is at a maximum at $x = 5$ cm, and the field is directed to the right there.
C) The electric field is zero at $x = 10$ cm, its magnitude is at a maximum at $x = 5$ cm, and the field is directed to the left there.
D) The electric field is zero at $x = 5$ cm, its magnitude is at a maximum at $x = 0$, and the field is directed to the right there.

123. The charge on the square plates of a parallel–plate capacitor is $Q$. The potential across the plates is maintained with constant voltage by a battery as they are pulled apart to twice their original separation, which is small compared to the dimensions of the plates. The amount of charge on the plates is now equal to
A) $Q/2$. B) $2Q$. C) $4Q$. D) $Q/4$. E) $Q$.

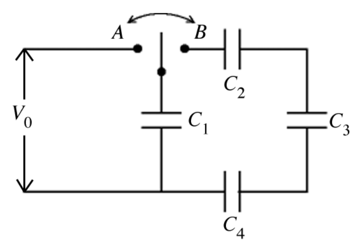
124. The electric field between square the plates of a parallel–plate capacitor has magnitude $E$. The potential across the plates is maintained with constant voltage by a battery as they are pulled apart to twice their original separation, which is small compared to the dimensions of the plates. The magnitude of the electric field between the plates is now equal to
A) $E$. B) $4E$. C) $E/4$. D) $E/2$. E) $2E$.

125. Equal but opposite charges $Q$ are placed on the square plates of an air–filled parallel–plate capacitor. The plates are then pulled apart to twice their original separation, which is small compared to the dimensions of the plates. Which of the following statements about this capacitor are true? (There may be more than one correct choice.)
A) The capacitance has doubled.
B) The energy stored in the capacitor has doubled.
C) The potential difference across the plates has doubled.
D) The electric field between the plates has increased.
E) The energy density in the capacitor has increased.

126. When two or more capacitors are connected in series across a potential difference
A) the equivalent capacitance of the combination is less than the capacitance of any of the capacitors.
B) the potential difference across the combination is the algebraic sum of the potential differences across the individual capacitors.
C) each capacitor carries the same amount of charge.
D) All of the above choices are correct.
E) None of the above choices are correct.

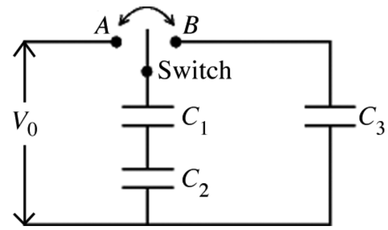
127. When two or more capacitors are connected in parallel across a potential difference
A) the potential difference across each capacitor is the same.
B) the equivalent capacitance of the combination is less than the capacitance of any of the capacitors.
C) each capacitor carries the same amount of charge.
D) All of the above choices are correct.
E) None of the above choices are correct.

128. The four identical capacitors in the circuit shown in the figure are initially uncharged. Let the charges on the capacitors be $Q_1, Q_2, Q_3$, and $Q_4$ and the potential differences across them be $V_1, V_2, V_3$, and $V_4$. The switch is thrown first to position $A$ and kept there for a long time. It is then thrown to position $B$. Which of the following conditions is true with the switch in position $B$?




A) $V_1 = V_0$
B) $Q_1 = Q_2$
C) $V_1 = V_2 = V_3 = V_4$
D) $V_1 + V_2 + V_3 + V_4 = V_0$
E) $Q_1 = 3\,Q_2$

129. In the circuit shown in the figure, the capacitors are initially uncharged. The switch is first thrown to position $A$ and kept there for a long time. It is then thrown to position $B$. Let the charges on the capacitors be $Q_1$, $Q_2$, and $Q_3$ and the potential differences across them be $V_1$, $V_2$, and $V_3$. Which of the following conditions must be true with the switch in position $B$?




A) $Q_1 + Q_2 = Q_3$
B) $V_3 = V_0$
C) $V_1 + V_2 = V_3$
D) $V_1 = V_2 = V_3$
E) $Q_1 = Q_2 = Q_3$

130. An ideal parallel–plate capacitor consists of a set of two parallel plates of area $A$ separated by a very small distance $d$. When this capacitor is connected to a battery that maintains a constant potential difference between the plates, the energy stored in the capacitor is $U_0$. If the separation between the plates is doubled, how much energy is stored in the capacitor?

A) $U_0/4$ B) $4U_0$ C) $U_0$ D) $U_0/2$ E) $2U_0$

131. An ideal parallel–plate capacitor consists of a set of two parallel plates of area $A$ separated by a very small distance $d$. When the capacitor plates carry charges $+Q$ and $-Q$, the capacitor stores energy $U_0$. If the separation between the plates is doubled, how much electrical energy is stored in the capacitor?

A) $4U_0$ B) $2U_0$ C) $U_0/4$ D) $U_0/2$ E) $U_0$

132. An ideal air–filled parallel–plate capacitor has round plates and carries a fixed amount of equal but opposite charge on its plates. All the geometric parameters of the capacitor (plate diameter and plate separation) are now DOUBLED. If the original capacitance was $C_0$, what is the new capacitance?

A) $C_0/2$ B) $C_0$ C) $2C_0$ D) $4C_0$ E) $C_0/4$

133. An ideal air–filled parallel–plate capacitor has round plates and carries a fixed amount of equal but opposite charge on its plates. All the geometric parameters of the capacitor (plate diameter and plate separation) are now DOUBLED. If the original energy stored in the capacitor was $U_0$, how much energy does it now store?

A) $U_0/4$ B) $U_0/2$ C) $4U_0$ D) $2U_0$ E) $U_0$

134. An ideal air–filled parallel–plate capacitor has round plates and carries a fixed amount of equal but opposite charge on its plates. All the geometric parameters of the capacitor (plate diameter and plate separation) are now DOUBLED. If the original energy density between the plates was $u_0$, what is the new energy density?

A) $4u_0$ B) $u_0$ C) $u_0/16$ D) $u_0/4$ E) $16u_0$

135. A charged capacitor stores energy $U$. Without connecting this capacitor to anything, dielectric having dielectric constant $K$ is now inserted between the plates of the capacitor, completely filling the space between them. How much energy does the capacitor now store?

A) $U$  B) $KU$  C) $\frac{U}{2K}$  D) $2KU$  E) $\frac{U}{K}$

136. Two capacitors, $C_1$ and $C_2$, are connected in series across a source of potential difference. With the potential source still connected, a dielectric is now inserted between the plates of capacitor $C_1$. What happens to the charge on capacitor $C_2$?

A) The charge on $C_2$ remains the same.
B) The charge on $C_2$ decreases.
C) The charge on $C_2$ increases.

137. An air–filled parallel–plate capacitor is connected to a battery and allowed to charge up. Now a slab of dielectric material is placed between the plates of the capacitor while the capacitor is still connected to the battery. After this is done, we find that

A) the charge on the capacitor had not changed.
B) the energy stored in the capacitor had decreased.
C) the voltage across the capacitor had increased.
D) the charge on the capacitor had increased.
E) None of these choices are true.

138. If the electric potential in a region is given by $V(x) = 6/x^2$, the $x$ component of the electric field in that region is

A) $6x$.  B) $-6x$.  C) $12x^{-3}$.  D) $12x$.  E) $-12x^{-3}$.

139. If the potential in a region is given by $V(x,y,z) = xy - 3z^{-2}$, then the $y$ component of the electric field in that region is

A) $-y$.  B) $x + y - 6z^{-3}$.  C) $-x$.  D) $x + y$.

140. In a certain region, the electric potential due to a charge distribution is given by the equation $V(x,y,z) = 3x^2y^2 + yz^3 - 2z^3x$, where $x$, $y$, and $z$ are measured in meters and $V$ is in volts. Calculate the magnitude of the electric field vector at the position $(x,y,z) = (1.0, 1.0, 1.0)$.

A) $-8.1$ V/m  B) 74 V/m  C) 2.0 V/m  D) 8.6 V/m  E) 4.3 V/m

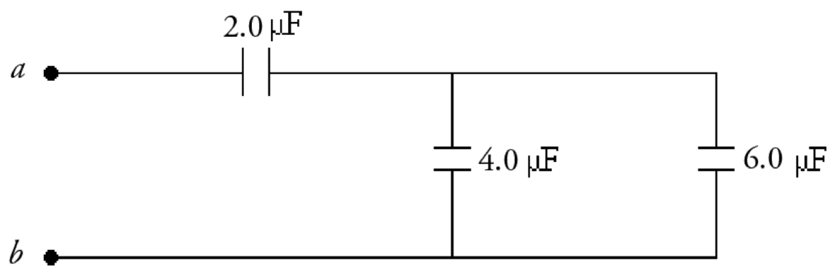
141. In a certain region, the electric potential due to a charge distribution is given by the equation $V(x,y) = 2xy - x^2 - y$, where $x$ and $y$ are measured in meters and $V$ is in volts. At which point is the electric field equal to zero?

A) $x = 1$ m, $y = 1$ m
B) $x = 0.5$ m, $y = 0.5$ m
C) $x = 1$ m, $y = 0.5$ m
D) $x = 0$ m, $y = 0$ m
E) $x = 0.5$ m, $y = 1$ m

142. Each plate of a parallel-plate air-filled capacitor has an area of 0.0020 $m^2$, and the separation of the plates is 0.020 mm. An electric field of $3.9 \times 10^6$ V/m is present between the plates. What is the surface charge density on the plates? ($\varepsilon_0 = 8.85 \times 10^{-12}\ C^2/N \cdot m^2$)

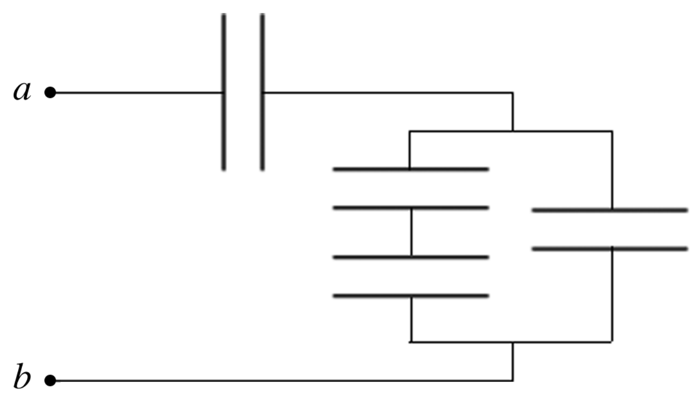
A) 17 $\mu C/m^2$ B) 87 $\mu C/m^2$ C) 35 $\mu C/m^2$ D) 52 $\mu C/m^2$ E) 73 $\mu C/m^2$

143. Three capacitors are connected as shown in the figure. What is the equivalent capacitance between points $a$ and $b$?



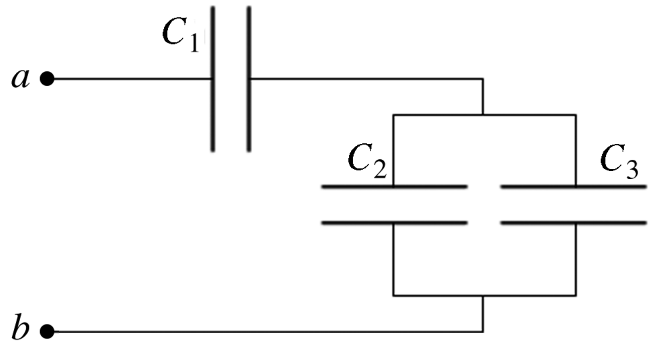

A) 12 $\mu$F B) 7.1 $\mu$F C) 4.0 $\mu$F D) 8.0 $\mu$F E) 1.7 $\mu$F

144. The capacitors in the network shown in the figure all have a capacitance of 5.0 $\mu$F. What is the equivalent capacitance, $C_{ab}$, of this capacitor network?



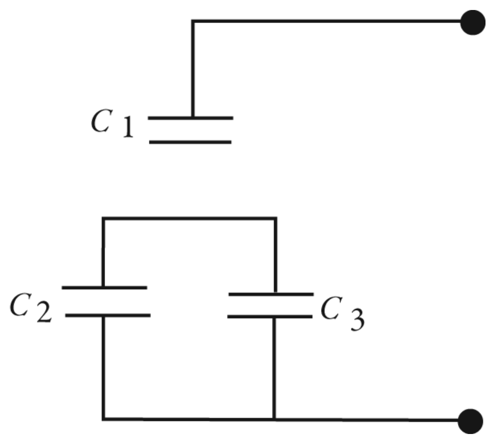

A) 5.0 $\mu$F B) 1.0 $\mu$F C) 20 $\mu$F D) 3.0 $\mu$F E) 10 $\mu$F

145. Three capacitors, with capacitances $C_1 = 4.0\ \mu F$, $C_2 = 3.0\ \mu F$, and $C_3 = 2.0\ \mu F$, are connected to a 12 -V voltage source, as shown in the figure. What is the charge on capacitor $C_2$?



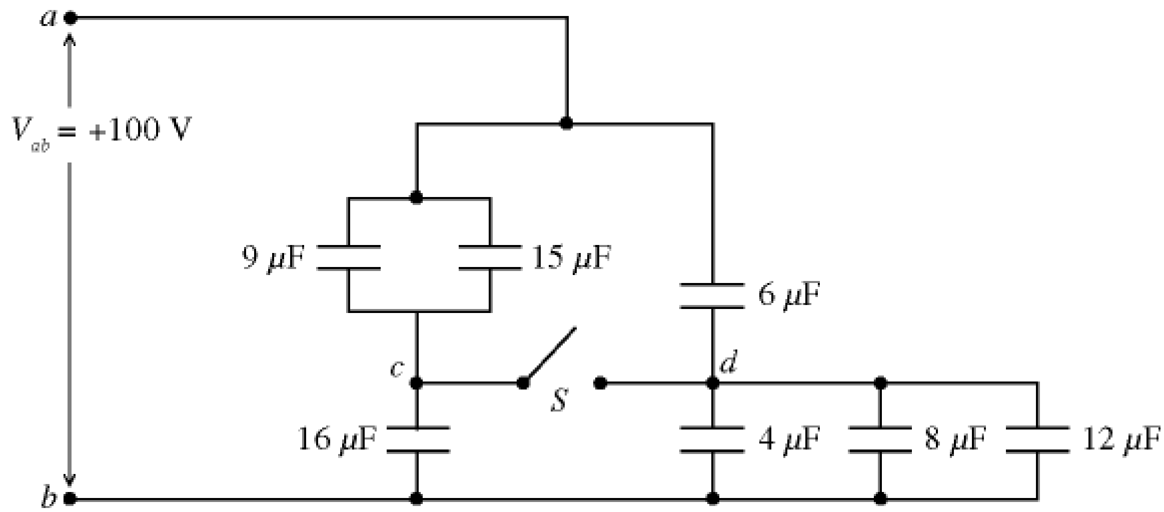

A) 2.0 μC  B) 32 μC  C) 16 μC  D) 4.0 μC  E) 8.0 μC

146. Three capacitors are arranged as shown in the figure. $C_1$ has a capacitance of 5.0 pF, $C_2$ has a capacitance of 10.0 pF, and $C_3$ has a capacitance of 15.0 pF. Find the voltage drop across the entire arrangement if the voltage drop across $C_2$ is 311 V.



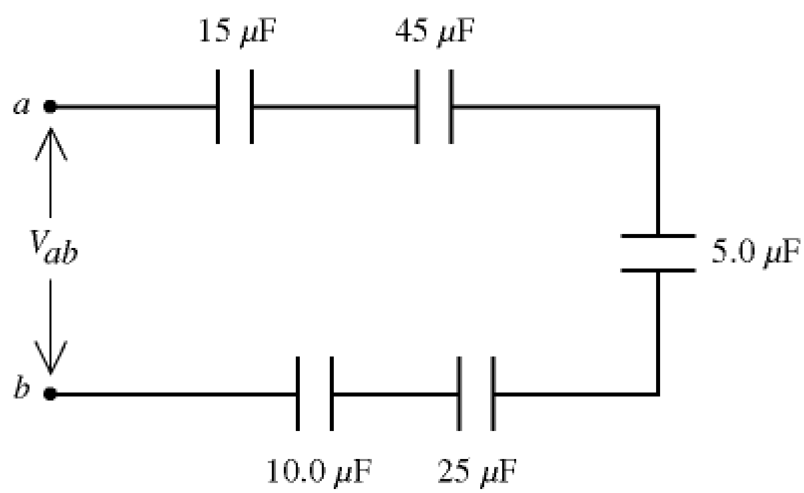

A) 1900 V  B) 1200 V  C) 520 V  D) 570 V

147. The capacitive network shown in the figure is assembled with initially uncharged capacitors. A potential difference, $V_{ab} = +100\text{V}$, is applied across the network. The switch $S$ in the network is kept open. Assume that all the capacitances shown are accurate to two significant figures. What is potential difference $V_{cd}$ across the open switch $S$?



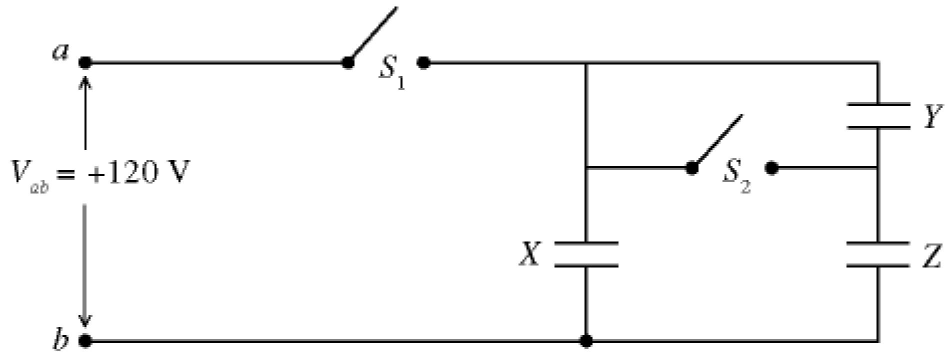

A) 50 V B) 0 V C) 70 V D) 40 V E) 60 V

148. Five capacitors are connected across a potential difference $V_{ab}$ as shown in the figure. Because of the dielectrics used, each capacitor will break down if the potential across it exceeds 30.0 V. The largest that $V_{ab}$ can be without damaging any of the capacitors is closest to




A) 64 V. B) 150 V. C) 6.0 V. D) 30 V. E) 580 V.

149. The network shown in the figure is assembled with uncharged capacitors $X$, $Y$, and $Z$, with $C_X = 7.0\ \mu F$, $C_Y = 7.0\ \mu F$, and $C_Z = 6.0\ \mu F$, and open switches, $S_1$ and $S_2$. A potential difference $V_{ab} = +120$ V is applied between points $a$ and $b$. After the network is assembled, switch $S_1$ is closed for a long time, but switch $S_2$ is kept open. Then switch $S_1$ is opened and switch $S_2$ is closed. What is the final voltage across capacitor $X$?




A) 94 V B) 71 V C) 63 V D) 79 V E) 87 V

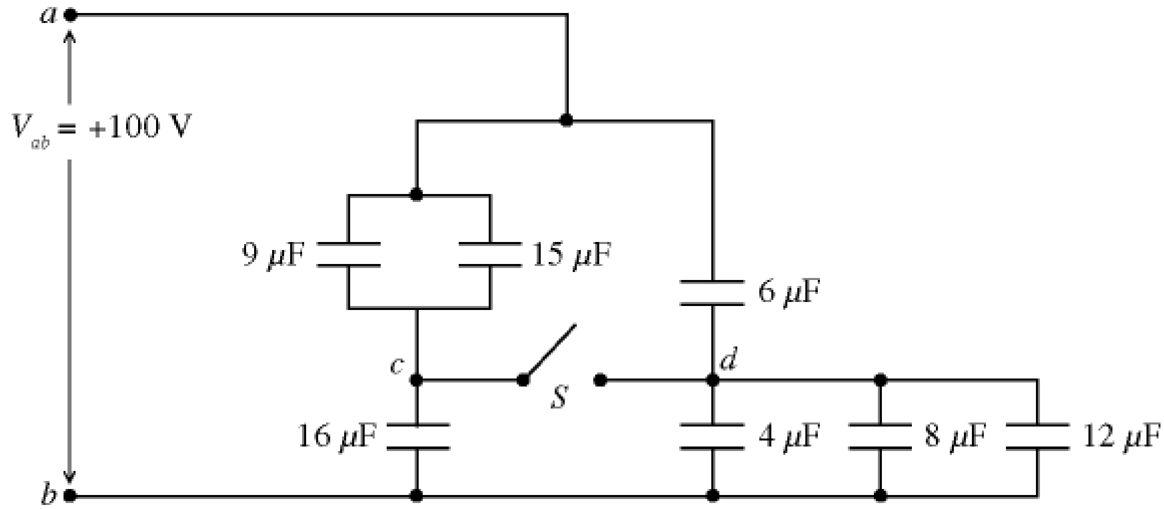
150. A 6.00-μF parallel-plate capacitor has charges of ±40.0 μC on its plates. How much potential energy is stored in this capacitor?
A) 133 μJ B) 143 μJ C) 113 μJ D) 103 μJ E) 123 μJ

151. A charge of 2.00 μC flows onto the plates of a capacitor when it is connected to a 12.0-V potential source. What is the minimum amount of work that must be done in charging this capacitor?
A) 24.0 μJ B) 576 μJ C) 12.0 μJ D) 144 μJ E) 6.00 μJ

152. A 1.0 μF capacitor has a potential difference of 6.0 V applied across its plates. If the potential difference across its plates is increased to 8.0 V, how much ADDITIONAL energy does the capacitor store?
A) 2.0 μJ B) 28 μJ C) 14 μJ D) 4.0 μJ

153. Two square air-filled parallel plates that are initially uncharged are separated by 1.2 mm, and each of them has an area of 190 $mm^2$. How much charge must be transferred from one plate to the other if 1.1 nJ of energy are to be stored in the plates? ($\varepsilon_0 = 8.85 \times 10^{-12}\ C^2/N \cdot m^2$)
A) 56 pC B) 3.5 μC C) 78 pC D) 39 pC

154. The capacitive network shown in the figure is assembled with initially uncharged capacitors. A potential difference, $V_{ab}$ = +100V, is applied across the network. The switch $S$ in the network is kept open. Assume that all the capacitances shown are accurate to two significant figures. What is the total energy stored in the seven capacitors?




A) 72 mJ B) 144 mJ C) 96 mJ D) 120 mJ E) 48 mJ

155. Each plate of an air-filled parallel-plate air capacitor has an area of 0.0040 $m^2$, and the separation of the plates is 0.080 mm. An electric field of $5.3 \times 10^6$ V/m is present between the plates. What is the energy density between the plates? ($\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N \cdot m^2$)

A) 170 J/$m^3$ B) 250 J/$m^3$ C) 210 J/$m^3$ D) 124 J/$m^3$ E) 84 J/$m^3$

156. A parallel-plate capacitor with plate separation of 1.0 cm has square plates, each with an area of $6.0 \times 10^{-2}$ $m^2$. What is the capacitance of this capacitor if a dielectric material with a dielectric constant of 2.4 is placed between the plates, completely filling them? ($\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N \cdot m^2$)

A) $64 \times 10^{-14}$ F
B) $1.3 \times 10^{-12}$ F
C) $1.3 \times 10^{-10}$ F
D) $15 \times 10^{-12}$ F
E) $15 \times 10^{-14}$ F

157. A parallel-plate capacitor has a capacitance of 10 mF and is charged with a 20-V power supply. The power supply is then removed and a dielectric material of dielectric constant 4.0 is used to fill the space between the plates. What is the voltage now across the capacitor?

A) 20 V B) 2.5 V C) 5.0 V D) 80 V E) 10 V

158. A 6.0-μF air-filled capacitor is connected across a 100-V voltage source. After the source fully charges the capacitor, the capacitor is immersed in transformer oil (of dielectric constant 4.5). How much ADDITIONAL charge flows from the voltage source, which remained connected during the process?

A) 2.1 mC B) 1.7 mC C) 1.5 mC D) 2.5 mC E) 1.2 mC

159. A parallel–plate capacitor has a capacitance of 10 mF and charged with a 20–V power supply. The power supply is then removed and a dielectric material of dielectric constant 4.0 is used to fill the space between the plates. How much energy is now stored by the capacitor?

A) 62.5 mJ B) 1200 mJ C) 250 mJ D) 500 mJ E) 125 mJ

160. A parallel–plate capacitor consists of two parallel, square plates that have dimensions 1.0 cm by 1.0 cm. If the plates are separated by 1.0 mm, and the space between them is filled with teflon, what is the capacitance of this capacitor? (The dielectric constant for teflon is 2.1, and $\varepsilon_0 = 8.85 \times 10^{-12}\ C^2/N \cdot m^2$.)

A) 2.1 pF B) 1.9 pF C) 0.44 pF D) 0.89 pF

161. An air–filled capacitor stores a potential energy of 6.00 mJ due to its charge. It is accidentally filled with water in such a way as not to discharge its plates. How much energy does it continue to store after it is filled? (The dielectric constant for water is 78 and for air it is 1.0006.)

A) 0.040 mJ B) 0.077 mJ C) 6.00 mJ D) 468 mJ

Answer Key
Testname: AP CH 25–29 TEST BANK

1. B
2. C
3. C
4. E
5. E
6. A
7. B
8. A
9. C
10. A
11. D
12. E
13. A
14. C
15. B
16. A
17. B
18. E
19. C
20. D
21. A
22. E
23. C
24. D
25. D
26. D
27. A
28. E
29. B
30. E
31. C
32. B
33. B
34. D
35. B
36. A
37. B
38. B
39. A
40. B
41. D
42. A
43. C
44. C
45. D
46. B
47. C
48. D
49. D
50. A
51. D
52. D
53. B
54. A, B
55. E
56. D, E
57. B
58. A
59. A
60. E
61. C
62. A
63. E
64. D
65. B
66. C
67. B
68. B
69. A
70. A
71. B
72. A
73. E
74. C
75. C
76. D
77. D
78. B
79. D
80. C
81. E
82. E
83. B
84. B
85. B
86. A
87. B
88. A
89. C
90. A, B, C
91. C
92. B
93. B
94. D
95. D
96. A
97. B
98. A
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100. A
101. B
102. D
103. A
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105. C
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137. D
138. C
139. C
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142. C
143. E
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145. C
146. A
147. D
148. A
149. A
150. A
151. C
152. C
153. A
154. A
155. D
156. C
157. C
158. A
159. D
160. B
161. B