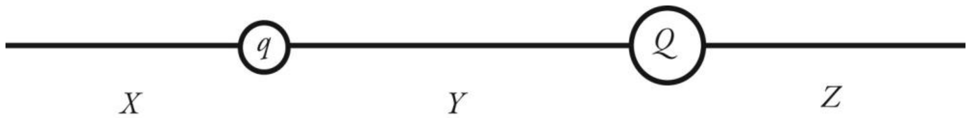
***Physics for Scientists and Engineers, 4e* (Knight)**
Chapter 23   The Electric Field

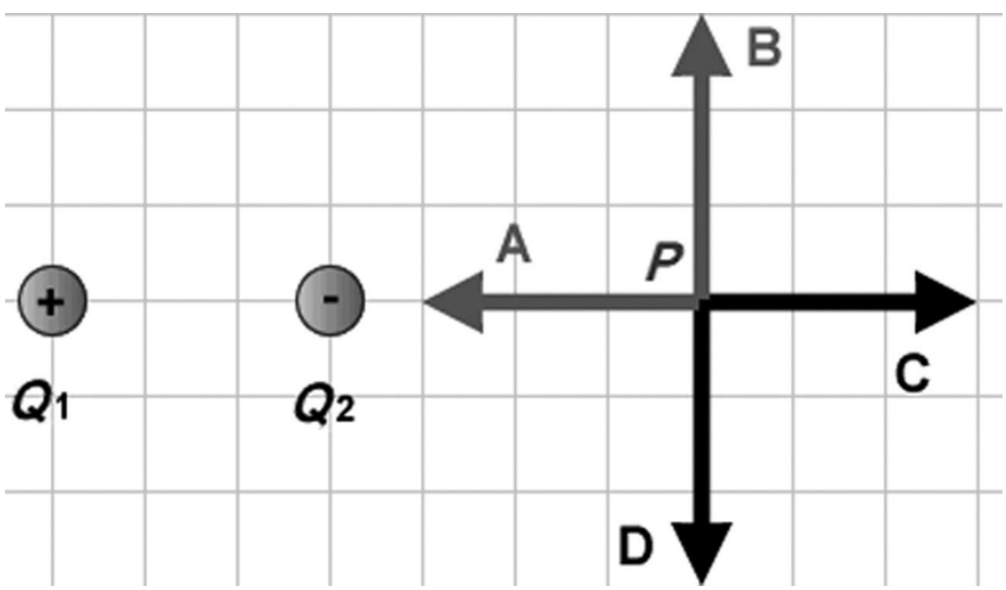
23.1   Conceptual Questions

1) 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 X
C) only region Y
D) only region Z
E) all three regions
Answer: B
Var: 1

2) 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.
Answer: A
Var: 1

3) 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) $\hat{\boldsymbol{j}}$.

B) $\hat{\boldsymbol{i}}$.

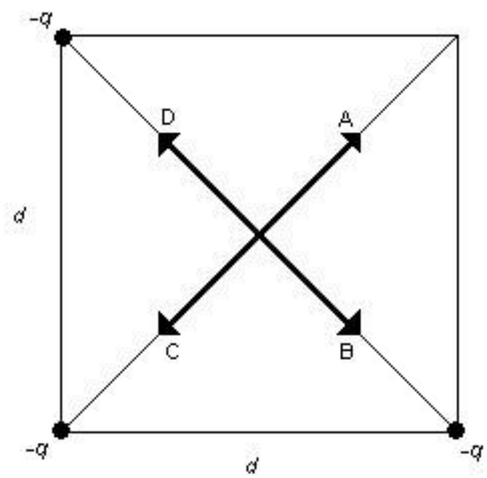
C) $-\hat{\boldsymbol{i}}$

D) $\hat{\boldsymbol{k}}$.

E) $-\hat{\boldsymbol{j}}$.

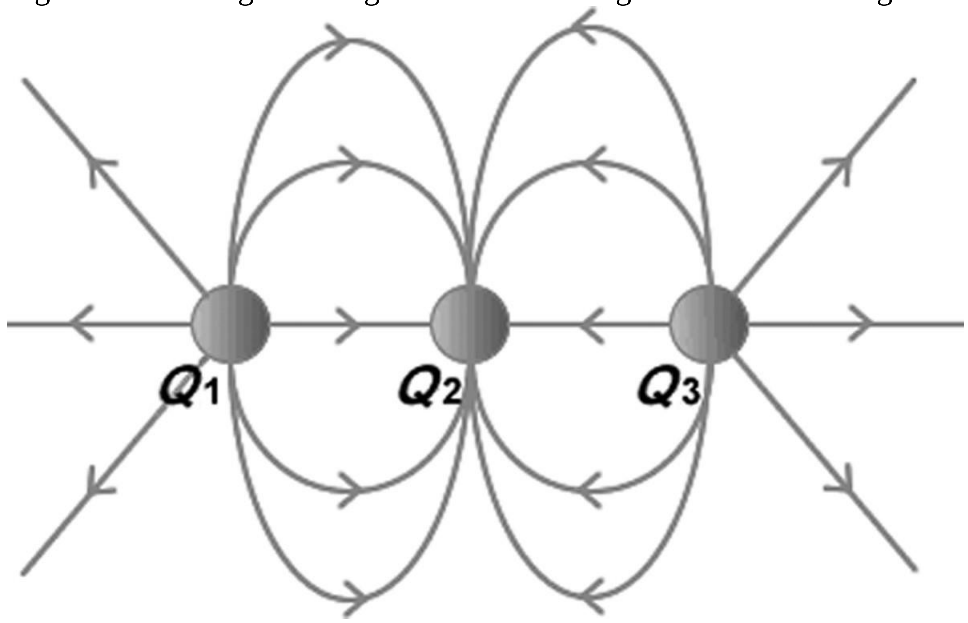
Answer: C
Var: 1

4) 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.
Answer: C
Var: 1

5) 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?

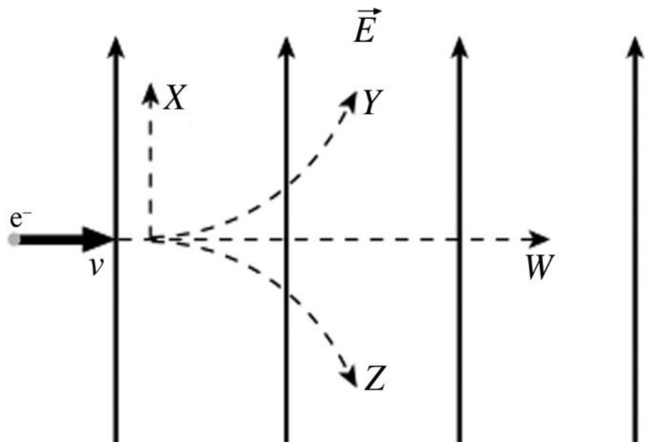


A) Q_1 is positive, Q_2 is negative, Q_3 is positive.
B) Q_1 is negative, Q_2 is positive, Q_3 is negative.
C) Q_1 is positive, Q_2 is positive, Q_3 is negative.
D) All three charges are negative.
E) All three charges are positive.
Answer: A
Var: 1

6) 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) $2E$
C) E
D) 0
E) $E/2$
Answer: C
Var: 1

7) 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) $4F$
B) $2F$
C) F
D) $F/2$
E) $F/4$
Answer: C
Var: 1

8) 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 W
B) trajectory X
C) trajectory Y
D) trajectory Z
Answer: D
Var: 1

23.2 Problems

1) 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) 25.2×10^6 N/C directed toward the negative charge

B) 25.2×10^6 N/C directed toward the positive charge

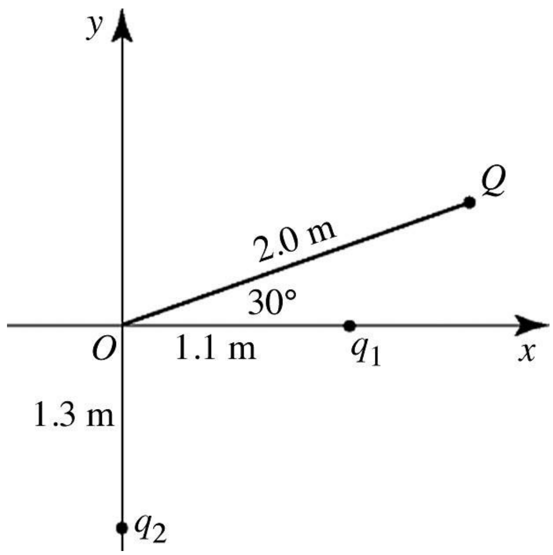
C) 25.2×10^5 N/C directed toward the negative charge

D) 25.2×10^5 N/C directed toward the positive charge

E) 25.2×10^4 N/C directed toward the negative charge

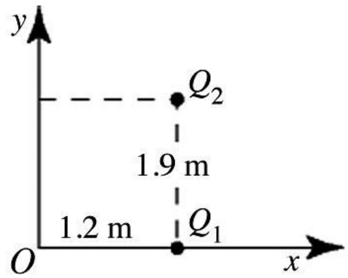
Answer: A
Var: 5

2) 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) 130 nC.
B) 76 nC.
C) 150 nC.
D) -76 nC.
E) -130 nC.
Answer: A
Var: 1

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



A) 6.0×10^{-3} N/C.
B) -6.0×10^{-3} N/C.
C) 3.8×10^{-3} N/C.
D) -3.8×10^{-3} N/C.
E) 7.1×10^{-3} N/C.
Answer: A
Var: 1

4) Three +3.0-μC point charges are at the three corners of a square of side 0.50 m. The last corner is occupied by a -3.0-μC charge. Find the magnitude of the electric field at the center of the square. ($k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9$ N · m^2/C^2)
Answer: 4.3×10^5 N/C
Var: 1

5) Three equal negative point charges are placed at three of the corners of a square of side d. What is the magnitude of the net electric field at the center of the square? ($k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9$ N · m^2/C^2)
Answer: E = $2kq/d^2$
Var: 1

6) A 5.0-μC point charge is placed at the 0.00 cm mark of a meter stick and a -4.0-μC point charge is placed at the 50 cm mark. At what point on a line joining the two charges is the electric field due to these charges equal to zero?
Answer: 4.7 m from the 0.00-cm mark
Var: 1

7) A 3.0-μC positive point charge is located at the origin and a 2.0 μC 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, $y = 0.55$ m
B) $x = 0.00$ m, $y = 0.67$ m
C) $x = 0.00$ m, $y = 1.5$ m
D) $x = 0.00$ m, $y = 0.60$ m
Answer: A
Var: 35

8) Two thin 80.0-cm rods are oriented at right angles to each other. Each rod has one end at the origin of the coordinates, and one of them extends along the +x-axis while the other extends along the +y-axis. The rod along the +x-axis carries a charge of -15.0 μC distributed uniformly along its length, and the other rod carries +15.0 μC uniformly over its length. Find the magnitude and direction of the net electrical force that these two rods exert on an electron located at the point (40.0 cm, 40.0 cm). ($e = 1.60 \times 10^{-19}$ C, $\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N \cdot m^2$)
Answer: 1.35×10^{-13} N at 135° with respect to the +x-axis
Var: 1

9) 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) 7.9 N/C
B) 3.9 N/C
C) 0.49 N/C
D) 0.031 N/C
Answer: A
Var: 50+

10) 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) -0.052 nC
C) -0.044 nC
D) -0.056 nC
Answer: A
Var: 50+

11) 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) (-3.6×10^3 N/C) $\hat{\boldsymbol{i}}$

B) (1.8×10^3 N/C) $\hat{\boldsymbol{j}}$

C) (-1.8×10^3 N/C) $\hat{\boldsymbol{k}}$

D) (3.6×10^3 N/C) $\hat{\boldsymbol{i}}$

E) zero

Answer: D

Var: 1

12) 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.
($\varepsilon_0 = 8.85 \times 10^{-12}\ C^2/N \cdot m^2$)

A) 9.95×10^5 N/C

B) 4.98×10^5 N/C

C) 3.31×10^5 N/C

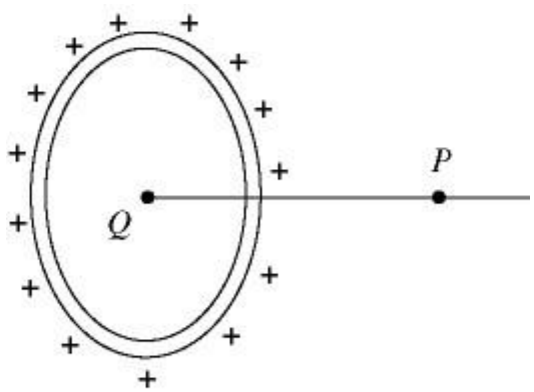
D) 2.49×10^5 N/C

E) 1.99×10^5 N/C

Answer: C

Var: 1

13) 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. (ε_0 = 8.85 × 10^{-12} $C^2/N \cdot m^2$) The point charge Q is closest to



A) -210.
B) -300.
C) -420.
D) 210.
E) 300.
Answer: A
Var: 1

14) 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 μC/m^2. Plate B is located at y = -1.0 cm and carries a uniform surface charge density +2.00 μC/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)?
(ε_0 = 8.85 × 10^{-12} $C^2/N \cdot m^2$)
A) (+1.13 × 10^5 N/C) $\hat{\boldsymbol{i}}$
B) (-2.83 × 10^5 N/C) $\hat{\boldsymbol{j}}$
C) (+1.19 × 10^5 N/C) $\hat{\boldsymbol{j}}$
D) (+1.69 × 10^5 N/C) $\hat{\boldsymbol{j}}$
E) (-1.19 × 10^5 N/C) $\hat{\boldsymbol{j}}$
Answer: A
Var: 1

15) 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) 4.2×10^4 N/C
B) 1.4×10^4 N/C
C) 3.1×10^4 N/C
D) 0.00 N/C
E) 5.6×10^4 N/C
Answer: E
Var: 1

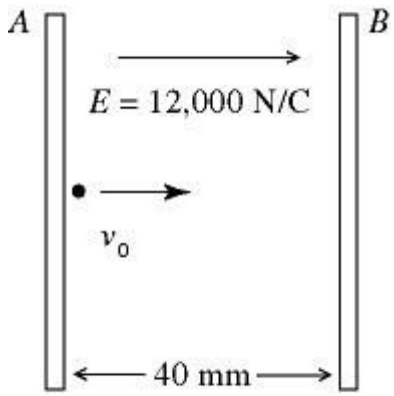
16) Two flat 4.0 cm × 4.0 cm electrodes carrying equal but opposite charges are spaced 2.0 mm apart with their midpoints opposite each other. Between the electrodes but not near their edges, the electric field strength is 2.5×10^6 N/C. What is the magnitude of the charge on each electrode? ($\varepsilon_0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

A) 35 nC
B) 18 nC
C) 16 nC
D) 30 nC
Answer: A
Var: 50+

17) The electric field strength in the space between two closely spaced parallel disks is .0 × 10^5 N/C. This field is the result of transferring 3.9×10^9 electrons from one disk to the other. What is the diameter of the disks? ($e = 1.60 \times 10^{-19}$ C, $\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N \cdot m^2$)

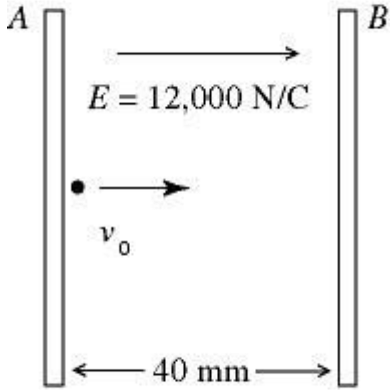
A) 3.0 cm
B) 1.5 cm
C) 4.5 cm
D) 6.0 cm
Answer: A
Var: 50+

18) 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



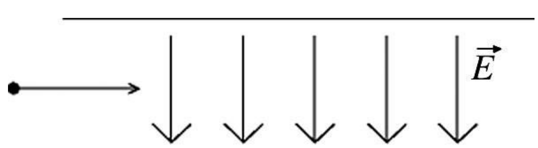
A) 1.2×10^7 m/s.
B) 1.5×10^7 m/s.
C) 1.8×10^7 m/s.
D) 2.1×10^7 m/s.
E) 2.4×10^7 m/s.
Answer: B
Var: 1

19) 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) 16 mm.
B) 18 mm.
C) 20 mm.
D) 22 mm.
E) 24 mm.
Answer: A
Var: 1

20) In the figure, a proton is projected horizontally midway between two parallel plates that are separated by 0.50 cm. The electrical field due to the plates has magnitude 610,000 N/C between the plates away from the edges. If the plates are 5.60 cm long, find the minimum speed of the proton if it just misses the lower plate as it emerges from the field. ($e = 1.60 \times 10^{-19}$ C, $\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N \cdot m^2$, $m_{el} = 9.11 \times 10^{-31}$ kg)



Answer: 6.06×10^6 m/s
Var: 50+

21) 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 · m^2/C^2)

A) 0.56 $\hat{\boldsymbol{i}}$ N/C

B) -0.56 $\hat{\boldsymbol{i}}$ N/C

C) 0.28 $\hat{\boldsymbol{i}}$ N/C

D) -0.28 $\hat{\boldsymbol{i}}$ N/C

Answer: A
Var: 40

22) 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 $\vec{\boldsymbol{E}} = (3.0 \times 10^6$ N/C$)\,\hat{\boldsymbol{i}}$ to bring the dipole to its stable equilibrium position?

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

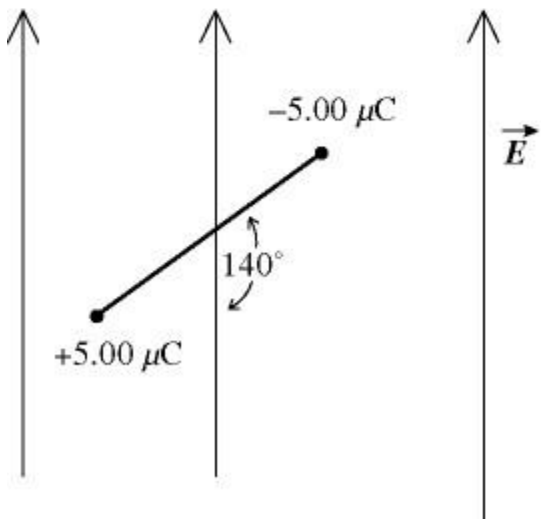
Answer: A
Var: 1

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

A) 2.00×10^{-3} N · m
B) 1.40×10^{-3} N · m
C) 2.80×10^{-3} N · m
D) 0.00 N · m
E) 1.00×10^{-3} N · m

Answer: E
Var: 1

24) An electric dipole consists of charges ±5.00 μC 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) 2.02×10^{-6} N · m.
B) 3.15×10^{-6} N · m.
C) 2.41×10^{-6} N · m.
D) 1.01×10^{-6} N · m.
E) 1.21×10^{-6} N · m.
Answer: A
Var: 1