Exam

Name_____

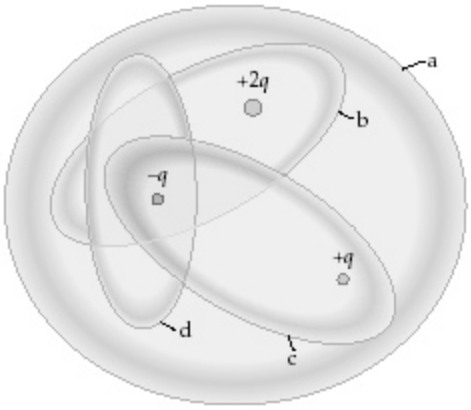
MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1) If the electric flux through a closed surface is zero, the electric field at points on that surface must be zero. 1) _____

A) True B) False

SHORT ANSWER. Write the word or phrase that best completes each statement or answers the question.

2) The figure shows four Gaussian surfaces surrounding a distribution of charges. 2) _____



(a) Which Gaussian surfaces have an electric flux of $+q/\varepsilon_0$ through them?

(b) Which Gaussian surfaces have no electric flux through them?

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

3) Which of the following statements about Gauss's law are correct? (There may be more than one correct choice.) 3) _____

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) Gauss's law is valid only for symmetric charge distributions, such as spheres and cylinders.

C) If there is no charge inside of a Gaussian surface, the electric field must be zero at points of that surface.

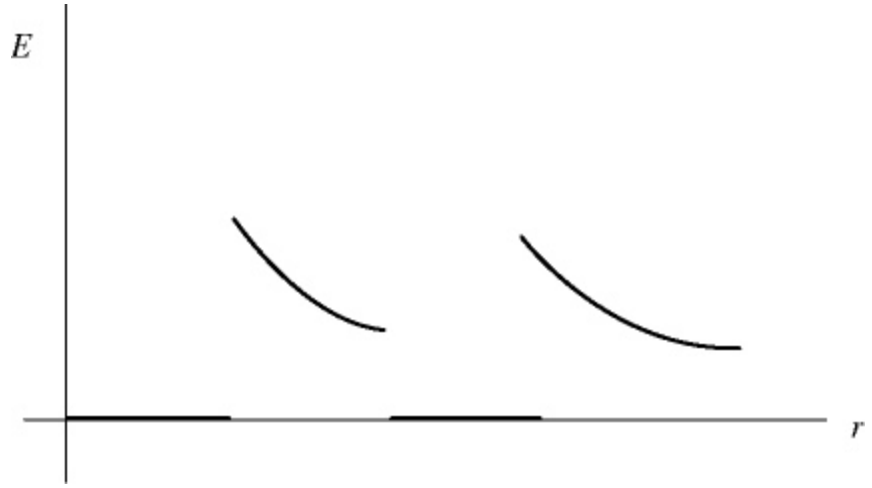
D) Only charge enclosed within a Gaussian surface can produce an electric field at points on that surface.

E) The electric flux passing through a Gaussian surface depends only on the amount of charge inside that surface, not on its size or shape.

4) 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 4) _____

A) at $x = 0, y = R/2, z = 0$.
B) at the origin.
C) at $x = 0, y = 0, z = R/2$.
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.

5) 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.) 5) _____



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

6) 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 6) _____

A) along a line between the lines closer to line #1 than line #2.
B) along a line between the lines closer to line #2 than line #1.
C) along a line perpendicular to lines #1 and #2.
D) at a point midway between the lines.

7) 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? 7) _____

A) $D/2$ B) $D/\sqrt{2}$ C) $2D$ D) $D/4$ E) $\sqrt{2}D$

8) 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? 8) _____

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

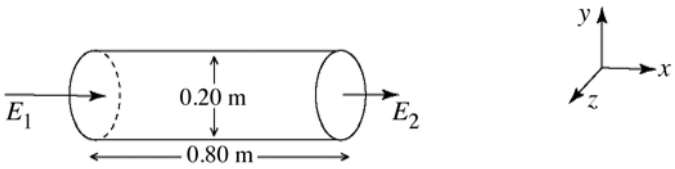
9) An uncharged conductor has a hollow cavity inside of it. Within this cavity there is a charge of +10 μC that does not touch the conductor. There are no other charges in the vicinity. Which statement about this conductor is true? (There may be more than one correct choice.) 9) _____

A) The outer surface of the conductor contains +10 μC of charge and the inner surface contains -10 μC.
B) The inner surface of the conductor carries a charge of -10 μC and its outer surface carries no excess charge.
C) The inner and outer surfaces of the conductor each contain charges of -5 μC.
D) The net electric field within the material of the conductor points away from the +10 μC charge.
E) Both surfaces of the conductor carry no excess charge because the conductor is uncharged.

10) Under electrostatic conditions, the electric field just outside the surface of any charged conductor 10) _____

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

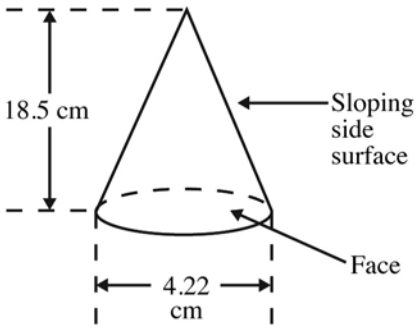
11) A nonuniform electric field is directed along the x-axis at all points in space. This magnitude of the field varies with x, but not with respect to y or z. The axis of a cylindrical surface, 0.80 m long and 0.20 m in diameter, is aligned parallel to the x-axis, as shown in the figure. The electric 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? 11) _____



A) -350 N · m^2/C
B) +160 N · m^2/C
C) 0.00 N · m^2/C
D) +350 N · m^2/C
E) -160 N · m^2/C

SHORT ANSWER. Write the word or phrase that best completes each statement or answers the question.

12) A cone is resting on a tabletop as shown in the figure with its face horizontal. A uniform electric field of magnitude 4550 N/C points vertically upward. How much electric flux passes through the sloping side surface area of the cone? 12) _____



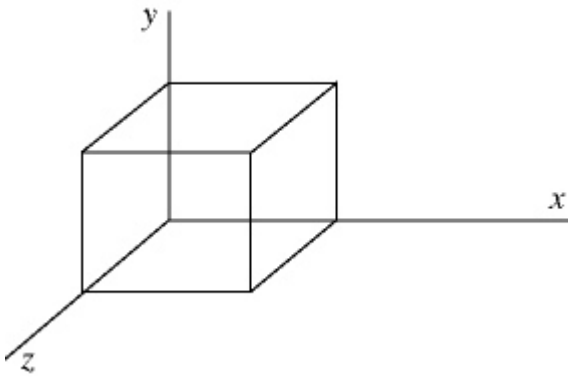
MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

13) 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? 13) _____

A) 45° B) 26.6° C) 60° D) 90° E) 30°

SHORT ANSWER. Write the word or phrase that best completes each statement or answers the question.

14) The cube of insulating material shown in the figure has one corner at the origin. Each side of the cube has length 0.080 m so the top face of the cube is parallel to the *xz*-plane and is at $y = 0.080$ m. It is observed that there is an electric field $\vec{E} = (3280 \text{ N/C} \cdot \text{m})y\hat{j}$ that is in the $+y$ direction and whose magnitude depends only on y. Use Gauss's law to calculate the net charge enclosed by the cube. ($\varepsilon_0 = 8.85 \times 10^{-12}$ C^2/N · m^2) 14) _____



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

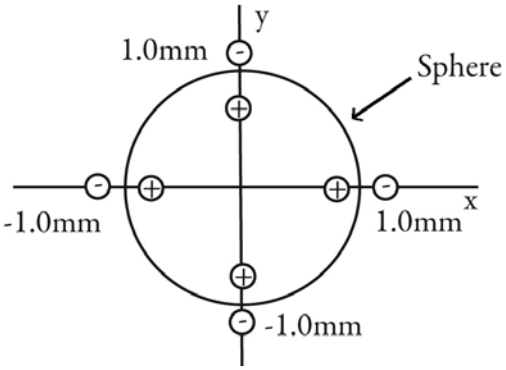
15) A charge $q = 2.00$ μC is placed at the origin in a region where there is already a uniform electric field $\vec{E} = (100 \text{ N/C})\hat{i}$. Calculate the flux of the net electric field through a Gaussian sphere of radius $R = 10.0$ cm centered at the origin. ($\varepsilon_0 = 8.85 \times 10^{-12}$ C^2/N · m^2) 15) _____

A) 1.13×10^5 N · m^2/C
B) 5.52×10^5 N · m^2/C
C) zero
D) 2.26×10^5 N · m^2/C

16) A charge of 1.0×10^{-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 · m^2) 16) _____

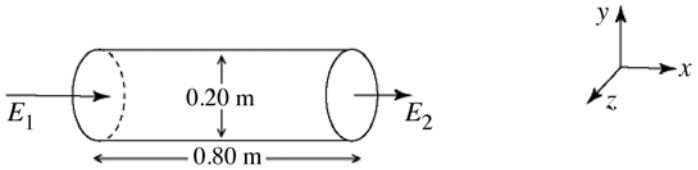
A) 0.11 N · m^2/C
B) 0.028π N · m^2/C
C) 8.9 N · m^2/C
D) It cannot be determined without knowing the radius of the sphere.

17) Four dipoles, each consisting of a +10-μC charge and a -10-μC 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 · m^2) 17) _____



A) 4.5×10^6 N · m^2/C
B) 11×10^5 N · m^2/C
C) 9.0×10^6 N · m^2/C
D) 0.00 N · m^2/C

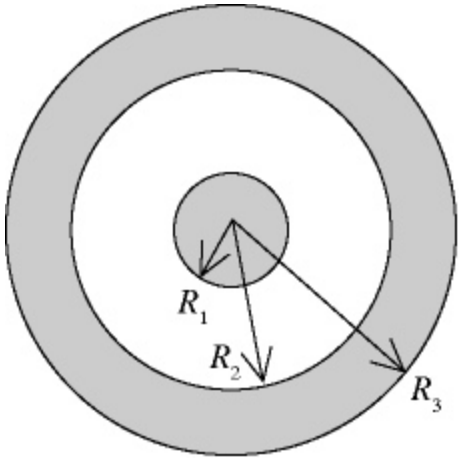
18) A nonuniform electric field is directed along the *x*-axis at all points in space. This magnitude of the field varies with *x*, but not with respect to *y* or *z*. The axis of a cylindrical surface, 0.80 m long and 0.20 m in diameter, is aligned parallel to the *x*-axis, as shown in the figure. The 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 · m^2) The charge enclosed by the cylindrical surface is closest to 18) _____



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

SHORT ANSWER. Write the word or phrase that best completes each statement or answers the question.

19) Two concentric spheres are shown in the figure. The inner sphere is a solid nonconductor and carries a charge of +5.00 μC uniformly distributed over its outer surface. The outer sphere is a conducting shell that carries a net charge of -8.00 μC. No other charges are present. The radii shown in the figure have the values R_1 = 10.0 cm, R_2 = 20.0 cm, and R_3 = 30.0 cm. ($k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9$ N · m^2/C^2)
(a) Find the total excess charge on the inner and outer surfaces of the conducting sphere.
(b) Find the magnitude and direction of the electric field at the following distances r from the center of the inner sphere: (i) r = 9.5 cm, (ii) r = 15.0 cm, (iii) r = 27.0 cm, (iv) r = 35.0 cm. 19) _____



20) Two concentric conducting spherical shells produce a radially outward electric field of magnitude 49,000 N/C at a point 4.10 m from the center of the shells. The outer surface of the larger shell has a radius of 3.75 m. If the inner shell contains an excess charge of -5.30 μC, find the amount of charge on the outer surface of the larger shell. ($k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9$ N · m^2/C^2) 20) _____

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

21) 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 $r_2 = 2R$? 21) _____

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

22) 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 22) _____

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

23) 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) 23) _____

A) 5.75×10^3 N/C
B) 2.87×10^6 N/C
C) zero
D) 2.87×10^3 N/C
E) 5.75×10^6 N/C

24) 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? 24) _____

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

25) 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? 25) _____

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

26) 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? 26) _____

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

SHORT ANSWER. Write the word or phrase that best completes each statement or answers the question.

27) A nonconducting spherical shell of inner radius R_1 and outer radius R_2 contains a uniform volume charge density ρ throughout the shell. Use Gauss's law to derive an equation for the magnitude of the electric field at the following radial distances r from the center of the sphere. Your answers should be in terms of ρ, R_1, R_2, r, ε_0, and π. 27) _____

(a) $r < R_1$

(b) $R_1 < r < R_2$

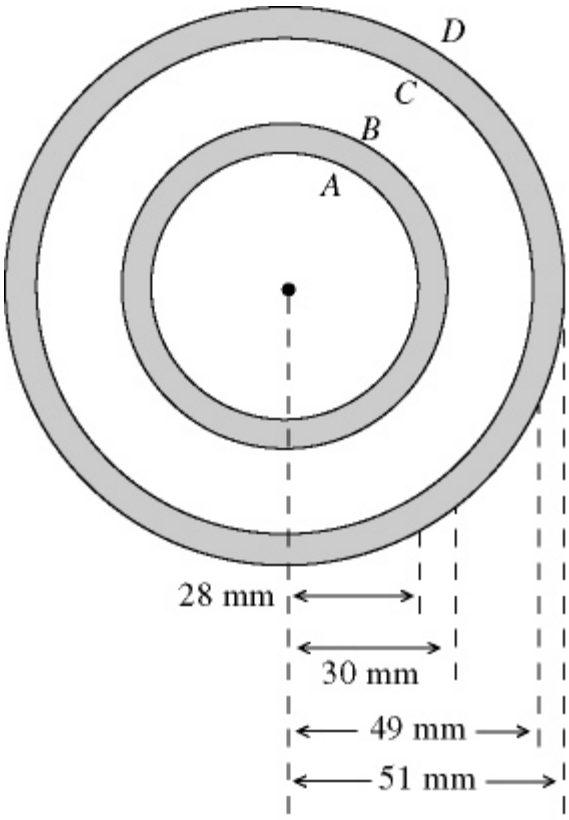
(c) $r > R_2$

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

28) 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. ($\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N \cdot m^2$) 28) _____

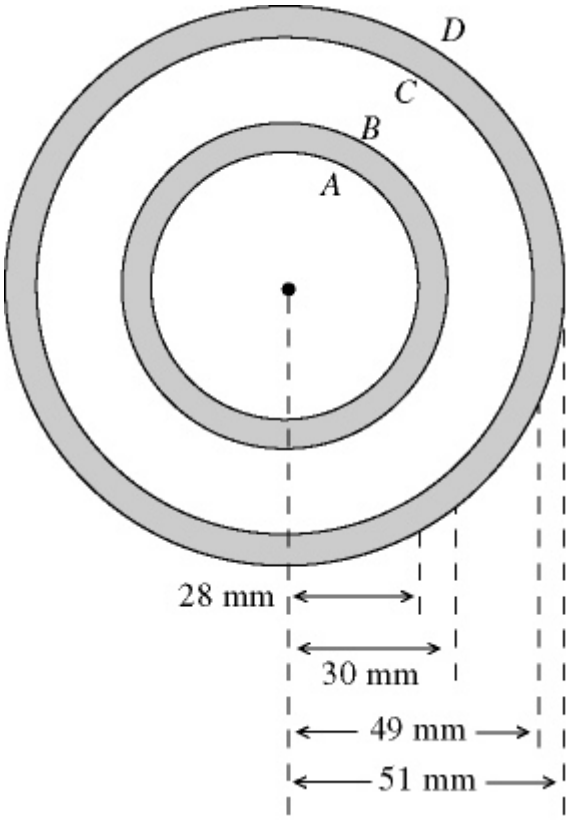
A) 5.10×10^3 N/C
B) 10.2×10^3 N/C
C) 2.00×10^3 N/C
D) 2.50×10^3 N/C
E) zero

29) 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 29) _____



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

30) 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. ($\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N \cdot m^2$) The magnitude of the electric field at a point that is 94 mm from the axis is closest to 30) _____



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

SHORT ANSWER. Write the word or phrase that best completes each statement or answers the question.

31) Charge is distributed uniformly throughout a large insulating cylinder of radius *R*. The charge per unit length in the cylindrical volume is λ. 31) _____
(a) Use Gauss's law to find the magnitude of the electric field at a distance *r* from the central axis of the cylinder for $r < R$. Your answer should be in terms of *r*, *R*, λ, ε_0 , and π.
(b) Check the reasonableness of your answer by evaluating it at the surface of the cylinder.

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

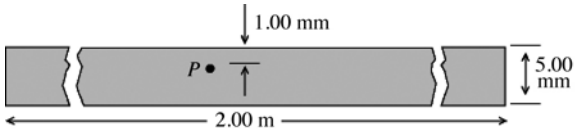
32) A very large sheet of a conductor carries a uniform charge density of 4.00 pC/mm^2 on its surfaces. What is the electric field strength 3.00 mm outside the surface of the conductor? ($\varepsilon_0 = 8.85 \times 10^{-12}$ C^2/N · m^2) 32) _____

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

33) 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 · m^2) 33) _____

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

34) As shown in the figure, a square insulating slab 5.0 mm thick measuring 2.0 m × 2.0 m has a charge of 8.0×10^{-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 · m^2) 34) _____



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

SHORT ANSWER. Write the word or phrase that best completes each statement or answers the question.

35) Two extremely large nonconducting horizontal sheets each carry uniform charge density on the surfaces facing each other. The upper sheet carries +5.00 μC/m^2. The electric field midway between the sheets is 4.25×10^5 N/C pointing downward. What is the surface charge density on the lower sheet? ($\varepsilon_0 = 8.85 \times 10^{-12}$ C^2/N · m^2) 35) _____

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

36) 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? 36) _____

A) $E = \dfrac{Q}{\varepsilon_0 L^2}$

B) $E = \dfrac{2Q}{\varepsilon_0 L^2}$

C) $E = \dfrac{Q}{2\varepsilon_0 L^2}$

D) $E = \dfrac{4Q}{\varepsilon_0 L^2}$

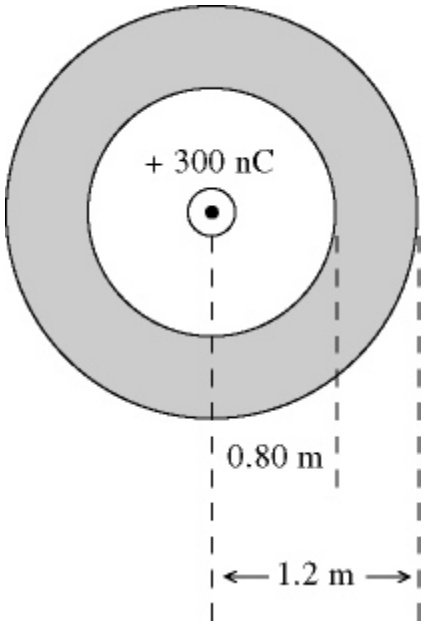
E) $E = 0$

SHORT ANSWER. Write the word or phrase that best completes each statement or answers the question.

37) A neutral hollow spherical conducting shell of inner radius 1.00 cm and outer radius 3.00 cm has a +2.00-μC point charge placed at its center. Find the surface charge density 37) _____
(a) on the inner surface of the shell.
(b) on the outer surface of the shell.

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

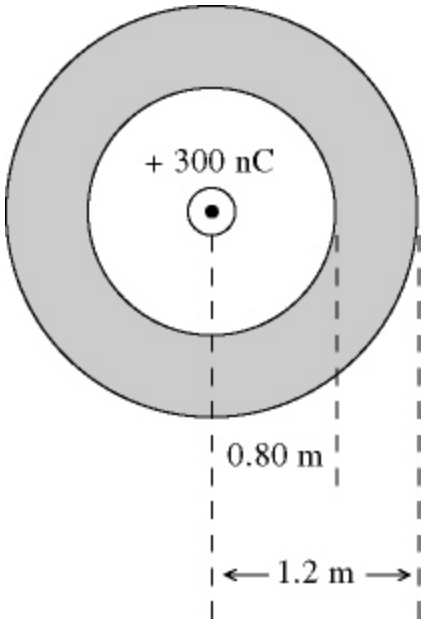
38) A hollow conducting spherical shell has radii of 0.80 m and 1.20 m, as shown in the figure. The sphere carries an excess charge of -500 nC. A point charge of +300 nC is present at the center. The surface charge density on the inner spherical surface is closest to 38) _____



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

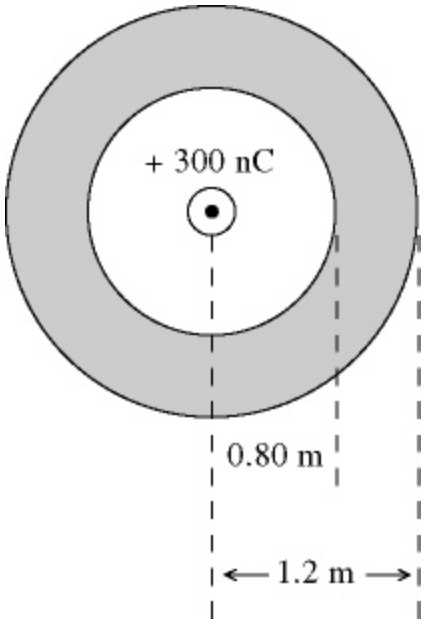
39) A hollow conducting spherical shell has radii of 0.80 m and 1.20 m, as shown in the figure. The sphere carries a net excess charge of -500 nC. A point charge of +300 nC is present at the center. ($k = 1/4\pi\varepsilon_0 = 8.99 \times 10^9$ N · m^2/C) The radial component of the electric field at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

39) _____



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

40) 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 40) _____



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

SHORT ANSWER. Write the word or phrase that best completes each statement or answers the question.

41) An irregular conductor carries a surface charge density of -6.75 μC/m^2 at and in the vicinity of a point *P* on the surface. An electron is released just above *P* outside the conductor. What are the magnitude and direction of its acceleration the instant after it is released? ($\varepsilon_0 = 8.85 \times 10^{-12}$ C^2/N · m^2, $e = 1.60 \times 10^{-19}$ C, $m_{el} = 9.11 \times 10^{-31}$ kg) 41) _____

1) B
2) (a) b (b) c
3) A, E
4) E
5) A, D
6) A
7) A
8) A
9) A
10) E
11) E
12) 6.36 N · m^2/C
13) C
14) 1.5 x 10^{-11} C
15) D
16) A
17) A
18) A
19) (a) -5.00 μC (inner surface), -3.00 μC (outer surface)
(b) (i) 0; (ii) 2.00 × 10^6 N/C, radially outward; (iii) 0; (iv) 2.20 × 10^5 N/C, radially inward
20) 91.6 μC
21) C
22) E
23) B
24) A
25) B
26) A
27) (a) $E = 0$ (b) $E = \frac{\rho}{3\varepsilon_0 r^2}\left(r^3 - R_1^3\right)$ (c) $E = \frac{\rho}{3\varepsilon_0 r^2}\left(R_2^3 - R_1^3\right)$
28) B
29) A
30) D
31) (a) $E = \frac{\lambda r}{2\pi\varepsilon_0 R^2}$
(b) At $r = R$, $E = \lambda/2\pi\varepsilon_0 R$, which is reasonable.
32) E
33) B
34) D
35) -2.52 μC/m^2
36) A
37) (a) -1590 μC/m^2 (b) +177 μC/m^2
38) C
39) B
40) C
41) 1.34 × 10^{17} m/s^2, away from P