

Chapter 23: GAUSS' LAW

1. A total charge of $6.3 \times 10^{-8} \text{ C}$ is distributed uniformly throughout a 2.7-cm radius sphere. The volume charge density is:
A. $3.7 \times 10^{-7} \text{ C/m}^3$
B. $6.9 \times 10^{-6} \text{ C/m}^3$
C. $6.9 \times 10^{-6} \text{ C/m}^2$
D. $2.5 \times 10^{-4} \text{ C/m}^3$
E. $7.6 \times 10^{-4} \text{ C/m}^3$
ans: E
2. Charge is placed on the surface of a 2.7-cm radius isolated conducting sphere. The surface charge density is uniform and has the value $6.9 \times 10^{-6} \text{ C/m}^2$. The total charge on the sphere is:
A. $5.6 \times 10^{-10} \text{ C}$
B. $2.1 \times 10^{-8} \text{ C}$
C. $4.7 \times 10^{-8} \text{ C}$
D. $6.3 \times 10^{-8} \text{ C}$
E. $9.5 \times 10^{-3} \text{ C}$
ans: D
3. A spherical shell has an inner radius of 3.7 cm and an outer radius of 4.5 cm. If charge is distributed uniformly throughout the shell with a volume density of $6.1 \times 10^{-4} \text{ C/m}^3$ the total charge is:
A. $1.0 \times 10^{-7} \text{ C}$
B. $1.3 \times 10^{-7} \text{ C}$
C. $2.0 \times 10^{-7} \text{ C}$
D. $2.3 \times 10^{-7} \text{ C}$
E. $4.0 \times 10^{-7} \text{ C}$
ans: A
4. A cylinder has a radius of 2.1 cm and a length of 8.8 cm. Total charge $6.1 \times 10^{-7} \text{ C}$ is distributed uniformly throughout. The volume charge density is:
A. $5.3 \times 10^{-5} \text{ C/m}^3$
B. $5.3 \times 10^{-5} \text{ C/m}^2$
C. $8.5 \times 10^{-4} \text{ C/m}^3$
D. $5.0 \times 10^{-3} \text{ C/m}^3$
E. $6.3 \times 10^{-2} \text{ C/m}^3$
ans: D

5. When a piece of paper is held with one face perpendicular to a uniform electric field the flux through it is $25 \text{ N} \cdot \text{m}^2/\text{C}$. When the paper is turned 25° with respect to the field the flux through it is:
- 0
 - $12 \text{ N} \cdot \text{m}^2/\text{C}$
 - $21 \text{ N} \cdot \text{m}^2/\text{C}$
 - $23 \text{ N} \cdot \text{m}^2/\text{C}$
 - $25 \text{ N} \cdot \text{m}^2/\text{C}$
- ans: D
6. The flux of the electric field $(24 \text{ N/C})\hat{i} + (30 \text{ N/C})\hat{j} + (16 \text{ N/C})\hat{k}$ through a 2.0 m^2 portion of the yz plane is:
- $32 \text{ N} \cdot \text{m}^2/\text{C}$
 - $34 \text{ N} \cdot \text{m}^2/\text{C}$
 - $42 \text{ N} \cdot \text{m}^2/\text{C}$
 - $48 \text{ N} \cdot \text{m}^2/\text{C}$
 - $60 \text{ N} \cdot \text{m}^2/\text{C}$
- ans: D
7. Consider Gauss's law: $\oint \vec{E} \cdot d\vec{A} = q/\epsilon_0$. Which of the following is true?
- $\vec{E}$ must be the electric field due to the enclosed charge
 - If $q = 0$, then $\vec{E} = 0$ everywhere on the Gaussian surface
 - If the three particles inside have charges of $+q$, $+q$, and $-2q$, then the integral is zero
 - on the surface $\vec{E}$ is everywhere parallel to $d\vec{A}$
 - If a charge is placed outside the surface, then it cannot affect $\vec{E}$ at any point on the surface
- ans: C
8. A charged point particle is placed at the center of a spherical Gaussian surface. The electric flux Φ_E is changed if:
- the sphere is replaced by a cube of the same volume
 - the sphere is replaced by a cube of one-tenth the volume
 - the point charge is moved off center (but still inside the original sphere)
 - the point charge is moved to just outside the sphere
 - a second point charge is placed just outside the sphere
- ans: D
9. Choose the INCORRECT statement:
- Gauss' law can be derived from Coulomb's law
 - Gauss' law states that the net number of lines crossing any closed surface in an outward direction is proportional to the net charge enclosed within the surface
 - Coulomb's law can be derived from Gauss' law and symmetry
 - Gauss' law applies to a closed surface of any shape
 - According to Gauss' law, if a closed surface encloses no charge, then the electric field must vanish everywhere on the surface
- ans: E

10. The outer surface of the cardboard center of a paper towel roll:
- A. is a possible Gaussian surface
 - B. cannot be a Gaussian surface because it encloses no charge
 - C. cannot be a Gaussian surface since it is an insulator
 - D. cannot be a Gaussian surface because it is not a closed surface
 - E. none of the above
- ans: D
11. A physics instructor in an anteroom charges an electrostatic generator to $25\text{ }\mu\text{C}$, then carries it into the lecture hall. The net electric flux in $\text{N} \cdot \text{m}^2/\text{C}$ through the lecture hall walls is:
- A. 0
 - B. 25×10^{-6}
 - C. 2.2×10^5
 - D. 2.8×10^6
 - E. can not tell unless the lecture hall dimensions are given
- ans: D
12. A point particle with charge q is placed inside the cube but not at its center. The electric flux through any one side of the cube:
- A. is zero
 - B. is q/ϵ_0
 - C. is $q/4\epsilon_0$
 - D. is $q/6\epsilon_0$
 - E. cannot be computed using Gauss' law
- ans: E
13. A particle with charge $5.0\text{-}\mu\text{C}$ is placed at the corner of a cube. The total electric flux in $\text{N} \cdot \text{m}^2/\text{C}$ through all sides of the cube is:
- A. 0
 - B. 7.1×10^4
 - C. 9.4×10^4
 - D. 1.4×10^5
 - E. 5.6×10^5
- ans: E
14. A point particle with charge q is at the center of a Gaussian surface in the form of a cube. The electric flux through any one face of the cube is:
- A. q/ϵ_0
 - B. $q/4\pi\epsilon_0$
 - C. $q/3\epsilon_0$
 - D. $q/6\epsilon_0$
 - E. $q/12\epsilon_0$
- ans: D

15. The table below gives the electric flux in $\text{N} \cdot \text{m}^2/\text{C}$ through the ends and round surfaces of four Gaussian surfaces in the form of cylinders. Rank the cylinders according to the charge inside, from the most negative to the most positive.

	<u>left end</u>	<u>right end</u>	<u>rounded surface</u>
cylinder 1:	$+2 \times 10^{-9}$	$+4 \times 10^{-9}$	-6×10^{-9}
cylinder 2:	$+3 \times 10^{-9}$	-2×10^{-9}	$+6 \times 10^{-9}$
cylinder 3:	-2×10^{-9}	-5×10^{-9}	$+3 \times 10^{-9}$
cylinder 4:	$+2 \times 10^{-9}$	-5×10^{-9}	-3×10^{-9}

- A. 1, 2, 3, 4
- B. 4, 3, 2, 1
- C. 3, 4, 2, 1
- D. 3, 1, 4, 2
- E. 4, 3, 1, 2

ans: E

16. A conducting sphere of radius 0.01 m has a charge of $1.0 \times 10^{-9} \text{ C}$ deposited on it. The magnitude of the electric field in N/C just outside the surface of the sphere is:

- A. 0
- B. 450
- C. 900
- D. 4500
- E. 90,000

ans: C

17. A round wastepaper basket with a 0.15-m radius opening is in a uniform electric field of 300 N/C , perpendicular to the opening. The total flux through the sides and bottom, in $\text{N} \cdot \text{m}^2 \text{ C}$, is:

- A. 0
- B. 4.2
- C. 21
- D. 280
- E. can not tell without knowing the areas of the sides and bottom

ans: C

18. 10 C of charge are placed on a spherical conducting shell. A particle with a charge of -3 C is placed at the center of the cavity. The net charge on the inner surface of the shell is:

- A. -7 C
- B. -3 C
- C. 0 C
- D. $+3 \text{ C}$
- E. $+7 \text{ C}$

ans: D

19. 10 C of charge are placed on a spherical conducting shell. A particle with a charge of -3 C is placed at the center of the cavity. The net charge on the outer surface of the shell is:

A. -7 C
 B. -3 C
 C. 0 C
 D. $+3\text{ C}$
 E. $+7\text{ C}$

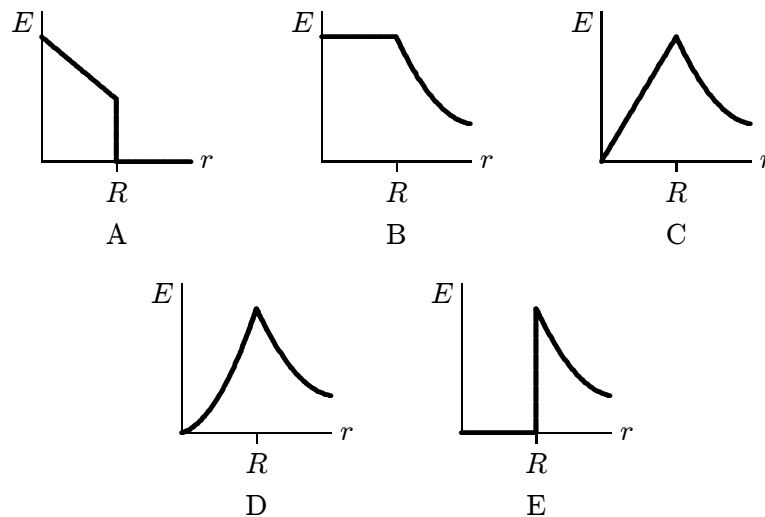
ans: E

20. A 30-N/C uniform electric field points perpendicularly toward the left face of a large neutral conducting sheet. The surface charge density in C/m^2 on the left and right faces, respectively, are:

A. $-2.7 \times 10^{-9}\text{ C/m}^2$; $+2.7 \times 10^{-9}\text{ C/m}^2$
 B. $+2.7 \times 10^{-9}\text{ C/m}^2$; $-2.7 \times 10^{-9}\text{ C/m}^2$
 C. $-5.3 \times 10^{-9}\text{ C/m}^2$; $+5.3 \times 10^{-9}\text{ C/m}^2$
 D. $+5.3 \times 10^{-9}\text{ C/m}^2$; $-5.3 \times 10^{-9}\text{ C/m}^2$
 E. 0; 0

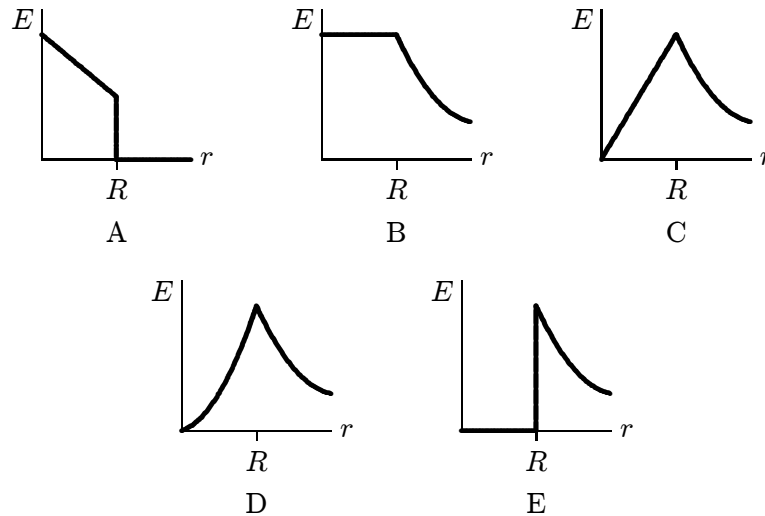
ans: A

21. A solid insulating sphere of radius R contains positive charge that is distributed with a volume charge density that does not depend on angle but does increase with distance from the sphere center. Which of the graphs below might give the magnitude E of the electric field as a function of the distance r from the center of the sphere?



ans: D

22. Which of the following graphs represents the magnitude of the electric field as a function of the distance from the center of a solid charged conducting sphere of radius R ?



ans: E

23. Charge Q is distributed uniformly throughout an insulating sphere of radius R . The magnitude of the electric field at a point $R/2$ from the center is:

- A. $Q/4\pi\epsilon_0 R^2$
- B. $Q/\pi\epsilon_0 R^2$
- C. $3Q/4\pi\epsilon_0 R^2$
- D. $Q/8\pi\epsilon_0 R^2$
- E. none of these

ans: D

24. Positive charge Q is distributed uniformly throughout an insulating sphere of radius R , centered at the origin. A particle with positive charge Q is placed at $x = 2R$ on the x axis. The magnitude of the electric field at $x = R/2$ on the x axis is:

- A. $Q/4\pi\epsilon_0 R^2$
- B. $Q/8\pi\epsilon_0 R^2$
- C. $Q/72\pi\epsilon_0 R^2$
- D. $17Q/72\pi\epsilon_0 R^2$
- E. none of these

ans: C

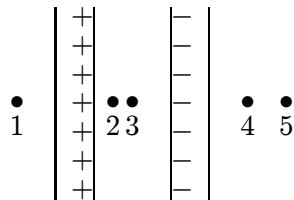
25. Charge Q is distributed uniformly throughout a spherical insulating shell. The net electric flux in $\text{N} \cdot \text{m}^2/\text{C}$ through the inner surface of the shell is:

- A. 0
- B. Q/ϵ_0
- C. $2Q/\epsilon_0$
- D. $Q/4\pi\epsilon_0$
- E. $Q/2\pi\epsilon_0$

ans: A

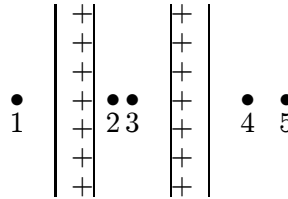
26. Charge Q is distributed uniformly throughout a spherical insulating shell. The net electric flux in $\text{N} \cdot \text{m}^2 / \text{C}$ through the outer surface of the shell is:
- A. 0
 - B. Q/ϵ_0
 - C. $2Q/\epsilon_0$
 - D. $Q/4\epsilon_0$
 - E. $Q/2\pi\epsilon_0$
- ans: B
27. A 3.5-cm radius hemisphere contains a total charge of $6.6 \times 10^{-7} \text{ C}$. The flux through the rounded portion of the surface is $9.8 \times 10^4 \text{ N} \cdot \text{m}^2 / \text{C}$. The flux through the flat base is:
- A. 0
 - B. $+2.3 \times 10^4 \text{ N} \cdot \text{m}^2 / \text{C}$
 - C. $-2.3 \times 10^4 \text{ N} \cdot \text{m}^2 / \text{C}$
 - D. $-9.8 \times 10^4 \text{ N} \cdot \text{m}^2 / \text{C}$
 - E. $+9.8 \times 10^4 \text{ N} \cdot \text{m}^2 / \text{C}$
- ans: C
28. Charge is distributed uniformly along a long straight wire. The electric field 2 cm from the wire is 20 N/C . The electric field 4 cm from the wire is:
- A. 120 N/C
 - B. 80 N/C
 - C. 40 N/C
 - D. 10 N/C
 - E. 5 N/C
- ans: D
29. Positive charge Q is placed on a conducting spherical shell with inner radius R_1 and outer radius R_2 . A particle with charge q is placed at the center of the cavity. The magnitude of the electric field at a point in the cavity, a distance r from the center, is:
- A. zero
 - B. $Q/4\pi\epsilon_0 R_1^2$
 - C. $q/4\pi\epsilon_0 r^2$
 - D. $(q + Q)/4\pi\epsilon_0 r^2$
 - E. $(q + Q)/4\pi\epsilon_0 (R_1^2 - r^2)$
- ans: C
30. Positive charge Q is placed on a conducting spherical shell with inner radius R_1 and outer radius R_2 . A point charge q is placed at the center of the cavity. The magnitude of the electric field at a point outside the shell, a distance r from the center, is:
- A. zero
 - B. $Q/4\pi\epsilon_0 r^2$
 - C. $q/4\pi\epsilon_0 r^2$
 - D. $(q + Q)/4\pi\epsilon_0 r^2$
 - E. $(q + Q)/4\pi\epsilon_0 (R_1^2 - r^2)$
- ans: D

31. Positive charge Q is placed on a conducting spherical shell with inner radius R_1 and outer radius R_2 . A point charge q is placed at the center of the cavity. The magnitude of the electric field produced by the charge on the inner surface at a point in the interior of the conductor, a distance r from the center, is:
- 0
 - $Q/4\pi\epsilon_0 R_1^2$
 - $Q/4\pi\epsilon_0 R_2^2$
 - $q/4\pi\epsilon_0 r^2$
 - $Q/4\pi\epsilon_0 r^2$
- ans: D
32. A long line of charge with λ_ℓ charge per unit length runs along the cylindrical axis of a cylindrical shell which carries a charge per unit length of λ_c . The charge per unit length on the inner and outer surfaces of the shell, respectively are:
- λ_ℓ and λ_c
 - $-\lambda_\ell$ and $\lambda_c + \lambda_\ell$
 - $-\lambda_\ell$ and $\lambda_c - \lambda_c$
 - $\lambda_\ell + \lambda_c$ and $\lambda_c - \lambda_\ell$
 - $\lambda_\ell - \lambda_c$ and $\lambda_c + \lambda_\ell$
- ans: B
33. Charge is distributed uniformly on the surface of a large flat plate. The electric field 2 cm from the plate is 30 N/C. The electric field 4 cm from the plate is:
- 120 N/C
 - 80 N/C
 - 30 N/C
 - 15 N/C
 - 7.5 N/C
- ans: C
34. Two large insulating parallel plates carry charge of equal magnitude, one positive and the other negative, that is distributed uniformly over their inner surfaces. Rank the points 1 through 5 according to the magnitude of the electric field at the points, least to greatest.



- 1, 2, 3, 4, 5
 - 2, then 1, 3, and 4 tied, then 5
 - 1, 4, and 5 tie, then 2 and 3 tie
 - 2 and 3 tie, then 1 and 4 tie, then 5
 - 2 and 3 tie, then 1, 4, and 5 tie
- ans: C

35. Two large parallel plates carry positive charge of equal magnitude that is distributed uniformly over their inner surfaces. Rank the points 1 through 5 according to the magnitude of the electric field at the points, least to greatest.



- A. 1, 2, 3, 4, 5
 B. 5, 4, 3, 2, 1
 C. 1, 4, and 5 tie, then 2 and 3 tie
 D. 2 and 3 tie, then 1 and 4 tie, then 5
 E. 2 and 3 tie, then 1, 4, and 5 tie
 ans: E
36. A particle with charge Q is placed outside a large neutral conducting sheet. At any point in the interior of the sheet the electric field produced by charges on the surface is directed:
 A. toward the surface
 B. away from the surface
 C. toward Q
 D. away from Q
 E. none of the above
 ans: C
37. A hollow conductor is positively charged. A small uncharged metal ball is lowered by a silk thread through a small opening in the top of the conductor and allowed to touch its inner surface. After the ball is removed, it will have:
 A. a positive charge
 B. a negative charge
 C. no appreciable charge
 D. a charge whose sign depends on what part of the inner surface it touched
 E. a charge whose sign depends on where the small hole is located in the conductor
 ans: C
38. A spherical conducting shell has charge Q . A particle with charge q is placed at the center of the cavity. The charge on the inner surface of the shell and the charge on the outer surface of the shell, respectively, are:
 A. 0, Q
 B. q , $Q - q$
 C. Q , 0
 D. $-q$, $Q + q$
 E. $-q$, 0
 ans: D