ÇANKAYA UNIVERSITY

PHYS 132 – PHYSICS II

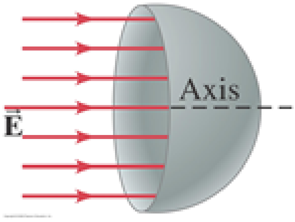
CHAPTER 23

GAUSS'S LAW

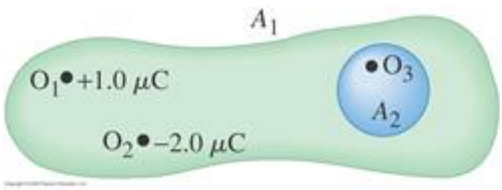
PROBLEM SET

1) A cube of side l, is placed in a uniform field E_0 with edges parallel to the field lines. (*a*) What is the net flux through the cube? (*b*) What is the flux through each of its six faces?**[Answer: a) Zero, b) For the faces parallel to the field lines, flux is zero; For the faces electric field lines entering, flux is $-El^2$ and For the faces electric field lines leaving, flux is $+El^2$]**

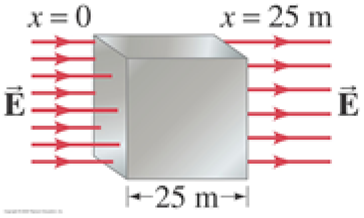
2) A uniform field $\vec{\mathbf{E}}$ is parallel to the axis of a hollow hemisphere of radius *r*, Fig. 22–25. (*a*) What is the electric flux through the hemispherical surface? (*b*) What is the result if $\vec{\mathbf{E}}$ is instead perpendicular to the axis?
[Answer: a)$\pi r^2 E$, b) 0]



3) In Fig. 22–27, two objects, O_1 and O_2, have charges $+1.0 \times 10^{-6}\ C$ and $-2.0 \times 10^{-6}\ C$ respectively, and a third object, O_3, is electrically neutral. (*a*) What is the electric flux through the surface A_1 that encloses all the three objects? (*b*) What is the electric flux through the surface A_2 that encloses the third object only? **[Answer: a) $-1.1 \times 10^5\ N \cdot m^2/C$, b) Zero]**



4) *** In a certain region of space, the electric field is constant in direction (say horizontal, in the x direction), but its magnitude decreases from $E = 560$ N/C at $x = 0$ to $E = 410$ N/C at $x = 25$ m. Determine the charge within a cubical box of side ***l=25*** m where the box is oriented so that four of its sides are parallel to the field lines (Fig. 22–28).**[Answer: $Q_{enc} = -8.3 \times 10^{-7}\ C$]**



5) *** A nonconducting sphere is made of two layers. The innermost section has a radius of 6.0 cm and a uniform charge density of $-5.0\ C/m^3$ The outer layer has a uniform charge density of $+8.0\ C/m^3$ and extends from an inner radius of 6.0cm to an outer radius of 12.0cm. Determine the electric field for (a) $0 < r < 6.0$ cm, (b) $6.0\text{ cm} < r < 12.0\text{ cm}$, and ($c$) $12.0\text{ cm} < r < 50.0\text{ cm}$.

[Answers: below

a)

$$\left(-1.9\times10^{11}\ \text{N/C}\cdot\text{m}\right)r$$

b)

$$\frac{\left(-1.1\times10^{8}\ \text{N}\cdot\text{m}^2/\text{C}\right)}{r^2} + \left(3.0\times10^{11}\ \text{N/C}\cdot\text{m}\right)r$$

c)

$$\frac{\left(4.1\times10^{8}\ \text{N}\cdot\text{m}^2/\text{C}\right)}{r^2}$$

]

6) A flat square sheet of thin aluminum foil, 25 cm on a side, carries a uniformly distributed 275 nC charge. What, approximately, is the electric field (a) 1.0 cm above the center of the sheet and (b) 15 m above the center of the sheet?

[Answer: a)2.5×10^5 N/C away from the sheet, b)11 N/C away from the sheet]

7) *** A very long solid nonconducting cylinder of radius R_1 is uniformly charged with a charge density ρ_E. It is surrounded by a concentric cylindrical tube of inner radius R_2 and outer radius R_3 as shown in Fig. 22–36, and it too carries a uniform charge density ρ_E. Determine the electric field as a function of the distance R from the center of the cylinders for (*a*) $0 < R < R_1$, (*b*) $R_1 < R < R_2$, (*c*) $R_2 < R < R_3$, and (*d*) $R > R_3$.

[Answers:

a)	b)	c)	d)
$\frac{\rho_E R}{2\varepsilon_0}$	$\frac{\rho_E R_1^2}{2\varepsilon_0 R}$	$\frac{\rho_E\left(R_1^2 + R^2 - R_2^2\right)}{2\varepsilon_0 R}$	$\frac{\rho_E\left(R_1^2 + R_3^2 - R_2^2\right)}{2\varepsilon_0 R}$

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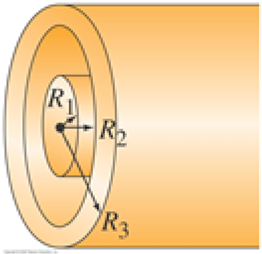


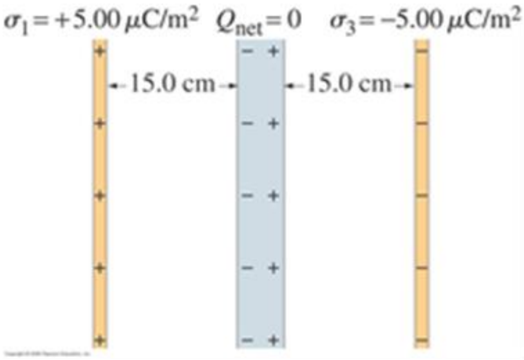
Fig. 22–36

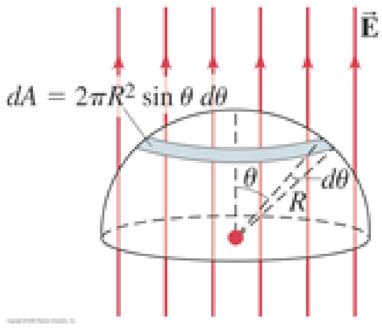
8) Suppose two thin flat plates measure 1.0 m $\times$ 1.0 m and are separated by 5.0 mm. They are oppositely charged with $\pm 15\ \mu C$ (*a*) Estimate the total force exerted by one plate on the other (ignore edge effects). (*b*) How much work would be required to move the plates from 5.0 mm apart to 1.00 cm apart?

[Answer: a)13 N towards the other plate, b)0.064 J]

9) Three very large sheets are separated by equal distances of 15.0 cm (Fig. 22–47). The first and third sheets are very thin and nonconducting and have charge per unit area **σ** of $+5.00\,\mu C/m^2$ and $-5.00\,\mu C/m^2$ respectively. The middle sheet is conducting but has no net charge. (*a*) What is the electric field inside the middle sheet? What is the electric field (*b*) between the left and middle sheets, and (*c*) between the middle and right sheets? (*d*) What is the charge density on the surface of the middle sheet facing the left sheet, and (*e*) on the surface facing the right sheet?

[Answer: a) $E = 0$, b)$E = 5.65 \times 10^5\ N/C$ to the right, c) $E = 5.65 \times 10^5\ N/C$ to the right, d)$\sigma_{left} = -5.00 \times 10^{-6}\ C/m^2$, e) $\sigma_{right} = +5.00 \times 10^{-6}\ C/m^2$]





10) A hemisphere of radius *R* is placed in a charge-free region of space where a uniform electric field exists of magnitude *E* directed perpendicular to the hemisphere's circular base (Fig. 22–50). (*a*) Using the definition of ϕ_E through an "open" surface, calculate (via explicit integration) the electric flux through the hemisphere. [*Hint*: In Fig. 22–50 you can see that, on the surface of a sphere, the infinitesimal area located between the angles θ and θ+dθ is $dA = (2\pi R sin\theta)(Rd\theta) = 2\pi R^2 sin\theta d\theta$](*b*) Choose an appropriate gaussian surface and use Gauss's law to much more easily obtain the same result for the electric flux through the hemisphere.

[Answer: a) $\pi r^2 E$, b) $\pi r^2 E$]