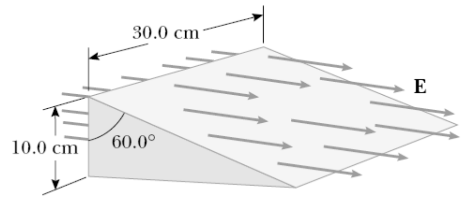
**DEGREE IN COMPUTER ENGINEERING**

**PHYSICS** **EXERCISES CH 4**

*Gauss' Law.*

**1.** Find the electric flux going through each side of the closed triangular prism in the figure, and the net electric flux, knowing that $\vec{E} = 150\vec{i}$ N/C.

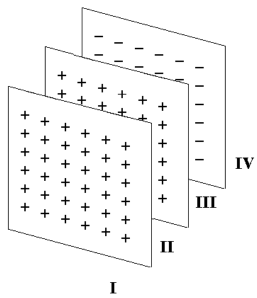



**2.** Calculate the electric flux produced by a positive Gadolinium ion $Gd^+$ through one of the faces of a cubic closed surface of l=1 m centred on the ion.

**3.** An electric field is $\vec{E} = 200\vec{i}$ N/C for x>0 and $\vec{E} = -200\vec{i}$ N/C for x<0. A closed cylinder of length 20 cm and radius R=5 cm has its centre at the origin and its axis along the x axis, so that one end is at x=10 cm and the other at x=-10 cm.
(a) What is the flux through each end?
(b) What is the flux through the curved surface of the cylinder?
(c) What is the net outward flux through the entire closed surface?
(d) What is the net charge enclosed in the cylinder?

**4.** (a) Use Gauss' law to find the electric field due to a line of charge with linear charge density $\lambda$ in all regions of space. (b) An infinite charged line with linear charge density $\lambda = -1.5$ μC/m is parallel to the Y axis on x = – 2 m, z = 0 m. A point charge of 1.3 μC is located at (1, 2, 0) m. Find the net electric field at (2, 1.5, 0) m.

**5.** Three infinite parallel plates have surface charge densities of $+\sigma$, $+\sigma$ and $-\sigma$, respectively. Find the magnitude and direction of the electric field on each of the four regions indicated in the figure.




**6.** A charged cylindrical foil of length 24 cm and radius 6 cm is centred at the origin of a Cartesian reference frame with its axis coinciding with the Y axis. It has a surface charge density of $\sigma$=9 nC/m$^2$.

(a) What is the total charge of the cylinder?

(b) Use Gauss' law to find the electric field due to an infinite cylindrical foil with surface charge density $\sigma$ in all regions of space.

(c) At which points of space could we use Gauss' Law to find the electric field due to the charged cylindrical foil of length 24 cm and radius 6 cm?

(d) Find the electric field at: (2, 0, 5) cm and (10, 0, 0) cm.

(e) Find the electric force acting on an electron located at (4,0,-2) cm.

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*Gauss' Law.*

**7.** (a) Find the electric field in all regions of space due to the following spherical charge distribution of radius R:

$\rho(r)=0$ $0<r<R/2$
$\rho(r)=\rho_o$ $R/2<r<R$ ($\rho_o$ constant)

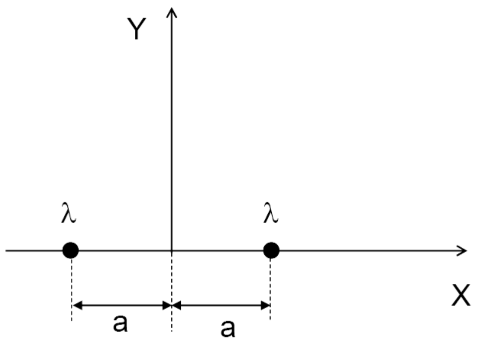
(b) Graphically represent E as a function of the distance r for this charge distribution.

(c) Considering R = 3 m and $\rho_o$= 8.85x10$^{-12}$ C/m$^3$, find the electric field at (2, - 4, 0) m in rectangular coordinates if the spherical charge distribution is centred at the origin of the reference frame.

**8.** A solid sphere of radius 20 cm is uniformly charged with a net charge of 10 nC. Deduce the electric field 5 cm away from its centre. Use Gauss' Law to find the electric field.

**9.** A solid sphere of radius $R_1$ has its centre on the X axis at $x=R_1$. It is uniformly charged with a volume charge density $\rho_0$. A spherical shell concentric with the solid sphere has a radius of $R_2$= $2R_1$ and a uniform surface charge density of $\sigma_0$. Find the magnitude of the electric field at ($R_1$/2, 0, 0), ($5R_1$/2, 0, 0) and ($2R_2$, $R_2$, 0).

**10.** Two infinite lines with linear charge density $\lambda$ >0 perpendicular to the XY plane are located at x = a and x =-a, as shown in the attached figure. Find the expression of the electric field for any point along the Y axis having y>0.

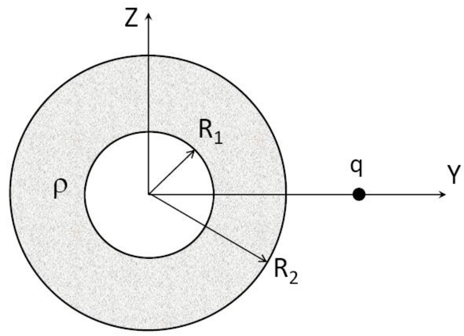



**11.** A hollow sphere with radii $R_1$ = 2 cm and $R_2$ = 4 cm (see figure) has a volume density $\rho$ = -3x10$^{-6}$ C/m$^3$. Also, there is a point charge of 4 $\mu$C located at (0, 6, 0) cm. Find:

(a) The total charge contained in the hollow sphere.

(b) The electric force on an electron located at (0, -3, 1) cm.

(c) The electric force on an electron located at (0, 0, 0) cm.



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**PHYSICS** **EXERCISES CH 4**

*Gauss' Law.*

**ANSWERS**

**1.** Back area : $\Phi = -4.5\,\dfrac{\mathrm{N.m^2}}{\mathrm{C}}$; Bottom area = Lateral areas : $\Phi = 0$; Top area : $\Phi = 4.5\,\dfrac{\mathrm{N.m^2}}{\mathrm{C}}$

$\Phi_{net} = 0$

**2.** $\Phi = 3.02 \times 10^{-9}\, Nm^2C^{-1}$

**3.** (a) $\Phi_{base1} = \Phi_{base2} = 0.5\pi$ N m$^2$/C (b) $\Phi_{lateral} = 0$ (c) $\Phi_{net} = \pi$ N m$^2$/C (d) $Q_{inside} = 2.78\ 10^{-11}$ C

**4.** (a) $\vec{E} = \dfrac{\lambda}{2\pi\varepsilon_0 r}\vec{u}_r\,(N/C)$ (b) $\vec{E} = 1.7\times10^3\,\vec{i} - 4.2\times10^3\,\vec{j}$ N/C

**5.** (Y axis: perpendicular to the plates; positive direction: from region I to region IV)

$\vec{E}_I = -\dfrac{\sigma}{2\varepsilon_0}\vec{j}$ ; $\vec{E}_{II} = \dfrac{\sigma}{2\varepsilon_0}\vec{j}$ ; $\vec{E}_{III} = \dfrac{3\sigma}{2\varepsilon_0}\vec{j}$ ; $\vec{E}_{IV} = \dfrac{\sigma}{2\varepsilon_0}\vec{j}$

**6.** (a) Q=0.814 nC (b) $\vec{E}_{inside} = 0$; $\vec{E}_{outside} = \dfrac{\sigma R}{\varepsilon_0 r}\vec{u}_r\,(N/C)$ (d) $\vec{\mathrm{E}}\,(2,0,5) = 0$, $\vec{\mathrm{E}}\,(10,0,0) = 610\,\vec{\mathrm{i}}$ N/C

(e) $F_e = 0$ (c) We can use GL at points (x, 0, z)

**7.** (a) $\vec{E}(r < R/2) = 0;\quad \vec{E}(R/2 < r < R) = \left(\dfrac{\rho_o r}{3\varepsilon_o} - \dfrac{\rho_o R^3}{24\varepsilon_o r^2}\right)\vec{u}_r;\quad \vec{E}(r > R) = \dfrac{7\rho_o R^3}{24\varepsilon_o r^2}\vec{u}_r$

(b) $\vec{E} = 0.18\vec{i} - 0.35\vec{j}$ (N/C)

**8.** $\vec{E} = 562\,\vec{u}_r$ (N/C)

**9.**

| Positions | E |
|---|---|
| ($R_1$/2, 0, 0) | $\dfrac{\rho_0 R_1}{6\varepsilon_0}$ |
| ($5R_1$/2, 0, 0) | $\dfrac{4\rho_0 R_1}{27\varepsilon_0}$ |
| ($4R_1$, $2R_1$, 0) | $\dfrac{1}{13\varepsilon_0}\left[\dfrac{\rho_0 R_1}{3} + 4\sigma_0\right]$ |

**10.**

$$\vec{E}(y) = \frac{\lambda\, y}{\pi\,\varepsilon_0\,(a^2 + y^2)}\ \vec{j}$$

**11.**

a) $Q_{esf} = -7.04 \times 10^{-10}$ C

b) $\vec{F} = 6.98 \times 10^{-13}\,\vec{j} - 7.71 \times 10^{-14}\,\vec{k}\quad [N]$

c) $\vec{F} = 1.6 \times 10^{-12}\,\vec{j}\quad [N]$