3 A uniform electric field $a\hat{i}+b\hat{j}$ intersects a surface of area A. What is the flux through this area if the surface lies (a) in the yz plane? (b) in the xz plane? (c) in the xy plane?

Sol. (a)

for yz plane

$\hat{i}, \hat{j}, \hat{k}$

$$\phi = E.A = (a\hat{i}+b\hat{j}) \cdot A\hat{i} = \boxed{aA}$$

$\hat{i}^2 = 1$

$\hat{i}\times\hat{j} = \hat{i}\times\hat{k} = 0$

(b) xz plane

$$\phi = E.A = (a\hat{i}+b\hat{j}) \cdot A\hat{j} = \boxed{bA}$$

(c) in the xy plane

$$\phi = E.A = (a\hat{i}+b\hat{j}) \cdot A\hat{k} = \boxed{0}$$

A point charge of 12 μC is placed at the center of a spherical shell of radius 22 cm. What is the total electric flux through (a) the entire surface of the shell and (b) any hemispherical surface of the shell? (c) Do the results depend on the radius? Explain.

Sol.

Given

$q_{in} = 12 \times 10^{-6}$ C

$\epsilon_0 = 8.85 \times 10^{-12}$ F/m $= C^2/N \cdot m^2$

for Gaussian sphere

See eq 24.5

$\phi_c = \frac{kq}{r^2}(4\pi r^2)$

$\phi_c = \frac{1}{4\pi\epsilon_0} \times \frac{q}{r^2} 4\pi r^2$

$= \frac{q}{\epsilon_0}$

is independent of r

(a)

$$\phi_c = \frac{q_{in}}{\epsilon_0} = \frac{12 \times 10^{-6}}{8.85 \times 10^{-12}} = \boxed{1.36 \times 10^{6} \ N m^2/C}$$

(b) for hemispherical (half of the sphere)

$$\phi_c = \frac{1.36 \times 10^{6}}{2} = 6.78 \times 10^{5} \ N m^2/C$$

(c) The results do not depend on the radius, since the equation 24.5 is independent of radius r.

3 A uniform electric field $a\hat{i}+b\hat{j}$ intersects a surface of area A. What is the flux through this area if the surface lies (a) in the yz plane? (b) in the xz plane? (c) in the xy plane?

Sol. (a)

for yz plane

$\hat{i}, \hat{j}, \hat{k}$

$$\phi = E.A = (a\hat{i}+b\hat{j}).A\hat{i} = \boxed{aA}$$

$\hat{i}^2 = 1$

$\hat{i}\times\hat{j} = \hat{i}\times\hat{k} = 0$

(b) xz plane

$$\phi = E.A = (a\hat{i}+b\hat{j}).A\hat{j} = \boxed{bA}$$

(c) in the xy plane

$$\phi = E.A = (a\hat{i}+b\hat{j}).A\hat{k} = \boxed{0}$$

A long, straight metal rod has a radius of 5 cm and a charge per unit length of $\lambda = 30\ nC/m$. Find the electric field at the following distances
(a) 3 cm, (b) 10 cm, (c) 100 cm.

[Given] $\lambda = 30\ nC/m = 30\times10^{-9}\ C$

radius of the rod, $r_0 = 5\ cm = .05\ m$

we have

$$E = \frac{1}{2\pi\epsilon_0}\frac{\lambda}{r}$$ see eq 24.9

see eq 24.9

$E = 2k\frac{\lambda}{r}$

λ is charge per unit length

(a) for $r = 3\ cm = .03\ m$

$E = 0$ since electric field is inside the conductor

(b) $r = 10\ cm = .1\ m$

$$\therefore E = \frac{30\times10^{-9}}{2\times3.14\times8.85\times10^{-12}\times.1} = 5395\ N/C$$

(c) $r = 100\ cm = 1\ m$

$$E = \frac{30\times10^{-9}}{2\pi(8.85\times10^{-12})\times1} = 540\ N/C$$