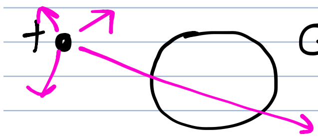
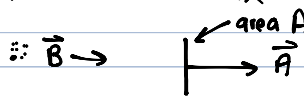
Open Source simulation on flux

- double charge → double flux
- change charge sign → change flux sign

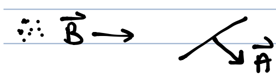
if I could move that central charge to lie outside the Gaussian sphere, the flux would be zero



Killer Bee flux



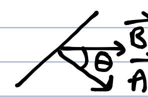
a lot of bees pass through

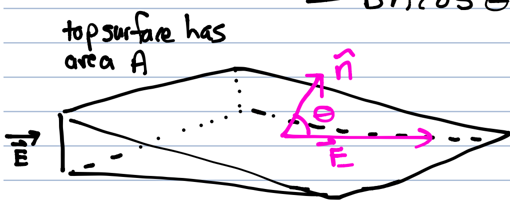


fewer bees pass through

Killer bee flux $\propto$ cosine angle between $\vec{B}$ and $\vec{A}$

$$= BA\cos\theta \quad = BA\,\hat{\imath}\cdot\hat{n} = \vec{B}\cdot\vec{A}$$



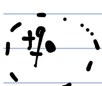


flux through top surface is
$\phi = EA\cos\theta = \vec{E}\cdot\vec{A}$

In this case, every E line passes through the Gaussian surface, so

$\phi_{net} = 0$

example E flux thru a sphere



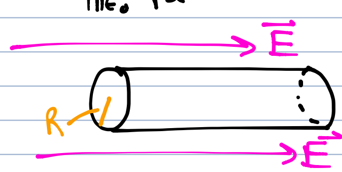
$E(r) = kq/r^2$

$$\phi = \int d\phi = \int \vec{E}\cdot d\vec{A} = \int E\,dA\,\underbrace{\hat{r}\cdot\hat{r}}_{\cos 0° = 1} = E\int dA = EA$$

$$= E\,4\pi r^2 = \frac{1}{4\pi\epsilon_0}\frac{q}{r^2}4\pi r^2 = \frac{q}{\epsilon_0}$$

example

E flux through a Gaussian cylinder immersed in a uniform $\vec{E}$?



$\phi_{net} = \phi_{left} + \phi_{right} + \phi_{tube}$

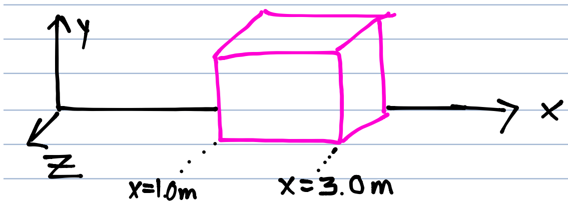
$$\phi_{net} = \int_{left} \vec{E}\cdot d\vec{A} + \int_{right} \vec{E}\cdot d\vec{A} + \int_{tube} \vec{E}\cdot d\vec{A}$$

$$= \int E\,dA \cos 180° + \int E\,dA \cos 0° + \int E\,dA \cos 90°$$

$$= -E\pi R^2 + E\pi R^2 + 0 = \boxed{0}$$

ch06/s1.html (B)

if you double the radius, A increases by factor of 4, but E(r) drops by factor of 4



ϕ_{net} for a non-uniform $\vec{E}$

$$\vec{E} = (3.0x\,\hat{i} + 4.0\,\hat{j})\ \frac{N}{C}$$

right face $\quad d\vec{A} = dA\,\hat{i}$

$$\phi_{right} = \int \vec{E}\cdot d\vec{A} = \int (3.0x\,\hat{i} + 4.0\hat{j})\cdot(dA\,\hat{i})$$

$$= \int [3.0x\,dA\,\hat{i}\cdot\hat{i} + 4.0\,dA\,\hat{j}\cdot\hat{i}]$$

$$= \int [3.0x\,dA + 0] = 3.0 \int x\,dA = 3.0\frac{N}{m\cdot C}\,3.0m \int dA = 9.0\frac{N}{C}\,A = 36\frac{Nm^2}{C}$$

left face

$$\phi_{left} = \frac{-1}{3}\phi_{right} \quad \text{since } d\vec{A} = -dA\,\hat{i} \text{ and } x = 1.0m \text{ not } 3.0m$$

$$= -12\ Nm^2/C$$

top face $\quad d\vec{A} = dA\,\hat{j}$

$$\phi_{top} = \int (3.0x\,\hat{i} + 4.0\hat{j})\,dA\,\hat{j} = \int (3.0x\,dA\,\hat{i}\cdot\hat{j} + 4.0\,dA\,\hat{j}\cdot\hat{j})$$

$$= \int (0 + 4.0\,dA) = 16\ Nm^2/C$$

$$\phi_{bottom} = -\phi_{top} = -16\ Nm^2/C \quad \text{since } d\vec{A} = dA(-\hat{j})$$

$$\phi_{front} = \phi_{back} = 0$$

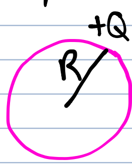
$$\phi_{tot} = 24\ Nm^2/C$$

Gauss' Law

$\phi_{electric} = Q_{enclosed}/\epsilon_0 = \oint \vec{E} \cdot d\vec{A}$ $\quad \oint \Rightarrow$ integrate over a closed surface

ch06/s2.html Mr. Brown charge adds nothing to the ϕ_{net} through any surface.

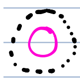
example $\vec{E}$ field for a thin spherical shell of charge $+Q$



a) inside shell

$$\phi = \int \vec{E} \cdot d\vec{A} = \frac{Q_{encl}}{\epsilon_0} = 0 \Rightarrow E = 0$$

b) outside shell E

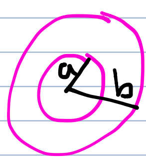


$$\vec{E} \cdot d\vec{A} = E\,dA \cos\theta = E\,dA$$

$$\int E\,dA = +Q/\epsilon_0 \quad \Rightarrow E \int dA = E 4\pi r^2 = +Q/\epsilon_0$$

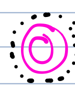
$$\Rightarrow E = \frac{1}{4\pi\epsilon_0} \frac{Q}{r^2}$$

example thick conducting shell of charge $+Q$, radii a and b



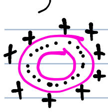
a) inside $r<a$ $Q_{encl} = 0 \Rightarrow E = 0$

b) outside $r>b$



$Q_{encl} = +Q \Rightarrow E 4\pi r^2 = Q/\epsilon_0 \Rightarrow E = K\frac{Q}{r^2}$

c) $a<r<b$



$Q_{encl} = 0 \Rightarrow E = 0$