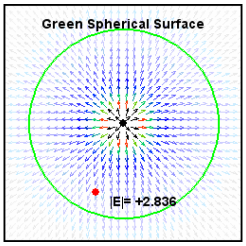
Worksheet for Exploration 24.1: Flux and Gauss's Law



In this Exploration, we will calculate the flux, Φ, through three Gaussian surfaces: green, red and blue **(position is given in meters and electric field strength is given in N/C)**. Note that this animation shows only two dimensions of a three-dimensional world. You will need to imagine that the circles you see are spheres.

Flux is a measure of the electric field through a surface. It is given by the following equation:

$$\Phi = \int_{\mathbf{surface}} \mathbf{E} \bullet d\mathbf{A} = \int_{\mathbf{surface}} E \cos\theta \, dA,$$

where **E** is the electric field, d**A** is the unit area normal to the surface and θ is the angle between the electric field vector and the surface normal.

Move the test charge along one of the Gaussian surfaces (you must imagine that it is a sphere even though you can only see a cross section of it).

a. What is the magnitude of the electric field along the surface?
   i. When you measure the electric field be careful and precise. Spend sufficient time to take good measurements.

   E_{green}=_________

   E_{red}=_________

   E_{blue}=_________

b. In what direction does it point?

c. What direction is normal to the Gaussian surface?
   i. that is …relative to the electric field direction in each case.

If the electric field, **E**, and the normal to the Gaussian surface, **A**, always point in the same direction relative to each other, and the electric field is constant, then the equation for flux becomes: $\Phi = E\cos\theta \int dA = EA\cos\theta$

d. In the case of the point charge in (a) – (c), what is the angle between the electric field and the normal to the surface?

This means that $\cos\theta = 1$. Therefore, for this case, $\Phi = EA$.

e. Calculate the flux for the surface you've chosen (remember that the surface area of a sphere is $4\pi R^2$).

i. Place all flux answers below in part f.

f. Calculate the flux for the other two surfaces.

Φ_{green}=_________

Φ_{red}=_________

Φ_{blue}=_________

Because the electric field decreases as $1/r^2$, but the area increases as r^2, the flux is the same for all three cases. This is the basis of Gauss's law: the flux through a Gaussian surface is proportional to the charge within the surface. With twice as much charge, there is twice as much flux. Gauss's law says that $\Phi = q_{enclosed}/\varepsilon_0$.

g. What is the magnitude and sign of the point charge?

q=________