$$\Phi = \int d\Phi = \frac{q}{4\pi\varepsilon_0} \underbrace{\int_0^{2\pi} d\phi}_{2\pi} \underbrace{\int_0^{\pi} \sin\theta \, d\theta}_{-\int_1^{-1} d(\cos\theta) = 2}$$

$\sin\theta \, d\theta = -d(\cos$

$\theta = 0, \cos\theta = 1$

$\theta = \pi, \cos\theta = -$

$$\therefore \Phi = \frac{q}{\varepsilon_0}$$

From the principle of superposition this result generalizes to multiple point charges q_i enclosed by S

$$\Phi = \frac{1}{\varepsilon_0} \sum_i q_i$$

or for a continuous charge we can do a volume integral.

$$\frac{1}{\varepsilon_0} \int_v \rho(\underline{r}') \, d\tau' = \Phi = \oint_S \underline{E} \cdot \underline{da} = \int_v \nabla \cdot \underline{E} \, d\tau'$$

where v is the volume enclosed by S

True for all v only if $\nabla \cdot \underline{E} = \rho / \varepsilon_0$