

$$F = \frac{1}{4\pi\epsilon_0} \frac{qQ}{r^2} \hat{r}, \quad \epsilon_0 = 8.854 \times 10^{-12}$$

$$F = QE$$

surface
(continuous)

$$E(r) = k \int \frac{1}{r^2} \hat{r} dq$$

$$E(r) = k \int \frac{\lambda}{r^2} \hat{r} dl'$$

$$E(r) = k \int \frac{\sigma}{r^2} \hat{r} da'$$

$$E(r) = k \int \frac{\rho}{r^2} \hat{r} d\tau'$$

dq
↓

$\lambda dl'$
↓

$\sigma da'$
↓

$\rho d\tau'$

$$E(r) = \frac{kq}{r^2} \hat{r} \quad \text{single pt. charge}$$

Flux through a surface \rightarrow

$$\oint_S \vec{E} \cdot d\vec{a} = \frac{1}{\epsilon_0} q_{\text{enclosed}} \rightarrow \text{Gauss's Law}$$

$$\boxed{\vec{\nabla} \cdot \vec{E} = \frac{\rho}{\epsilon_0}}$$

Remember, Stoke's Theorem

$$\oint_C \vec{A} \cdot d\vec{l} = \iint_S (\vec{\nabla} \times \vec{A}) \cdot d\vec{S}$$

$$\oint \vec{E} \cdot d\vec{l} = 0 \quad \text{so, } \boxed{\vec{\nabla} \times \vec{E} = 0}$$

$$\boxed{\vec{E} = -\vec{\nabla} V}$$

We know $\vec{\nabla} \cdot \vec{E} = \frac{\rho}{\epsilon_0}$ and this \rightarrow

so,

$$\boxed{\vec{\nabla}^2 V = -\frac{\rho}{\epsilon_0}} \rightarrow \text{Poisson's Equation}$$

regions with no charge $\rightarrow \rho = 0$

$$\text{so there, } \boxed{\vec{\nabla}^2 V = 0} \rightarrow \text{Laplace Equation}$$

$$V(r) = k \int \frac{\rho}{r} d\tau, \quad \vec{E}(r) = k \int \frac{\rho}{r^2} \hat{r} d\tau$$

$$\boxed{W = qV(r)} \quad \text{Point charge}$$

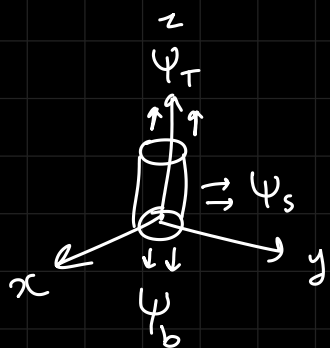
$$\boxed{W = \frac{1}{2} \int \rho V d\tau}$$

$$\boxed{W = \frac{\epsilon_0}{2} \int E^2 d\tau} \quad \text{all space}$$

Tut-2

$$g1) \quad \vec{G}(r) = 10e^{-2z} (f \hat{a}_\rho + \hat{a}_z)$$

$$\text{flux of } \vec{G} = \psi = \oint \vec{G} \cdot d\vec{s}$$



$$\psi = \psi_t + \psi_b + \psi_s$$

for the top \rightarrow

$$d\vec{s} = f df d\phi \hat{a}_z$$

$$\psi_t = \int \vec{G} \cdot d\vec{s} = \int_{f=0}^1 \int_{\phi=0}^{2\pi} 10e^{-2z} f df d\phi$$

Cylindrical coords \rightarrow

$$\vec{\nabla} \cdot \vec{A} = \frac{1}{f} \frac{\partial}{\partial f} (f A_f) + \frac{1}{f} \frac{\partial A_\phi}{\partial \phi} + \frac{\partial A_z}{\partial z}$$

$$\vec{\nabla}_x \vec{A} = \frac{1}{f} \begin{vmatrix} a_f & f a_\phi & a_z \\ \frac{\partial}{\partial f} & \frac{\partial}{\partial \phi} & \frac{\partial}{\partial z} \\ A_f & f A_\phi & A_z \end{vmatrix}$$

Spherical coords \rightarrow

$$\vec{\nabla} \cdot \vec{V} = \frac{1}{r^2} \frac{\partial}{\partial r} (r^2 V_r) + \frac{1}{r \sin \theta} \frac{\partial}{\partial \theta} (V_\theta \sin \theta) + \frac{1}{r \sin \theta} \frac{\partial}{\partial \phi} (V_\phi)$$

$$\vec{\nabla} \times \vec{A} = \begin{vmatrix} \hat{a}_r & \hat{a}_\theta & \hat{a}_\phi \\ \frac{1}{r^2 \sin \theta} \frac{\partial}{\partial r} & \frac{1}{r \sin \theta} \frac{\partial}{\partial \theta} & \frac{1}{r} \frac{\partial}{\partial \phi} \\ A_r & r A_\theta & r \sin \theta A_\phi \end{vmatrix}$$

NOTE: Vec Field = Irrotational
if its curl = 0