$F = \frac{1}{4\pi\varepsilon_0} \frac{qQ}{r^2} \hat{r}$, $\varepsilon_0 = 8.854 \times 10^{-12}$

$F = QE$

surface
(continous)

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

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

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

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

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

Flux through a surface →

$$\oint_S E \cdot da = \frac{1}{\varepsilon_0} Q_{enclosed}$$ → Gauss's Law

$$\boxed{\bar{\nabla} \bar{E} = \frac{\rho}{\varepsilon_0}}$$

Remember, Stoke's Theorem

$$\oint_C \vec{A} \cdot \vec{dl} = \iint_S (\vec{\nabla} \times \vec{A}) \cdot \vec{dS}$$

$\oint \bar{E} \cdot dl = 0$ so, $\boxed{\bar{\nabla} \times \bar{E} = 0}$

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

we know $\bar{\nabla} \bar{E} = \frac{\rho}{\varepsilon_0}$ and this

So, $\boxed{\bar{\nabla}^2 V = -\frac{\rho}{\varepsilon_0}}$ → Poisson's Equation

regions with no charge → $\rho = 0$

so there, $\boxed{\bar{\nabla}^2 V = 0}$ → Laplace Equation

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

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

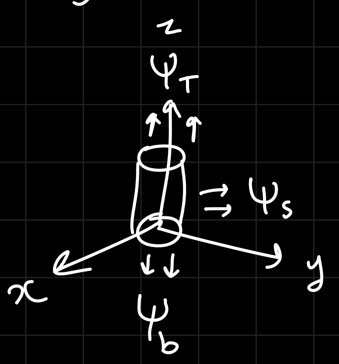
$$\boxed{W = \frac{1}{2} \int \rho V d\tau}$$

$$\boxed{W = \frac{\varepsilon_0}{2} \int_{\text{all space}} E^2 d\tau}$$

Tut - 2

Q1) $\bar{G}(r) = 10e^{-2z}(\rho\hat{a}_\rho + \hat{a}_z)$

flux of $\bar{G}$ $= \psi = \oint \bar{G}\cdot\bar{ds}$



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

for the top →

$\bar{ds} = \rho\, d\rho\, d\phi\, \hat{a}_z$

$$\psi_t = \int \bar{G}\cdot\bar{ds} = \int_{\rho=0}^{1}\int_{\phi=0}^{2\pi} 10e^{-2z}\rho\, d\rho\, d\phi$$

Cylindrical coords →

$$\bar{\nabla}\cdot\bar{A} = \frac{1}{\rho}\frac{\partial}{\partial\rho}(\rho A_\rho) + \frac{1}{\rho}\frac{\partial A_\phi}{\partial\phi} + \frac{\partial A_z}{\partial z}$$

$$\bar{\nabla}\times\bar{A} = \frac{1}{\rho}\begin{vmatrix} a_\rho & \rho a_\phi & a_z \\ \frac{\partial}{\partial\rho} & \frac{\partial}{\partial\phi} & \frac{\partial}{\partial z} \\ A_\rho & \rho A_\phi & A_z \end{vmatrix}$$

Spherical coords →

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

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

NOTE: Vec Field = Irrotational if its curl = 0