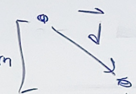
Relevant Equations for the Exam

Use if $\hat{d} = \pm\hat{x}$ or $\pm\hat{y}$ or you don't care about direction

Use if $\vec{d}$ is at an angle

$q_s \xrightarrow{\vec{d}} q_t$

$$\vec{F} = k\frac{q_s q_t}{d^2}\hat{d} = k\frac{q_s q_t}{d^3}\vec{d}$$



$$\vec{d} = (-2\hat{y} + 1\hat{x})$$

$$\hat{d} = \frac{\vec{d}}{d}$$

$q_s \xrightarrow{\vec{d}} \star$

$$\vec{E}_{pt} = k\frac{q_s}{d^2}\hat{d} = k\frac{q_s}{d^3}\vec{d} \qquad \vec{F} = q_t\vec{E}$$

Capital phi

$$\Phi_{\text{closed surface}} = \text{\# lines out} - \text{\# lines in}$$

$$\Phi \sim q_{enc.}$$

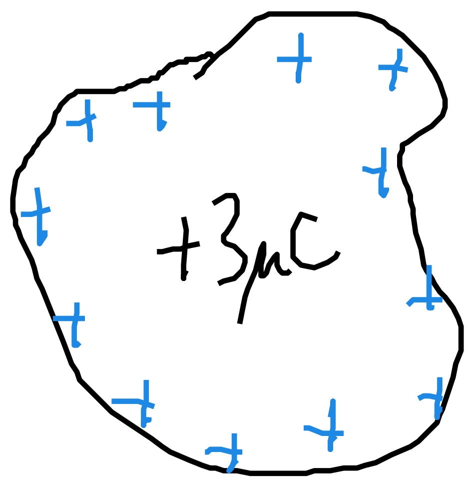
$$\lambda = \frac{Q}{L} \qquad \sigma = \frac{Q}{A} \qquad \rho = \frac{Q}{V}$$

$$\vec{E}_{line} = \frac{2k\lambda}{d}\widehat{away} \qquad \vec{E}_{sheet} = 2\pi k\sigma\,\widehat{away}$$

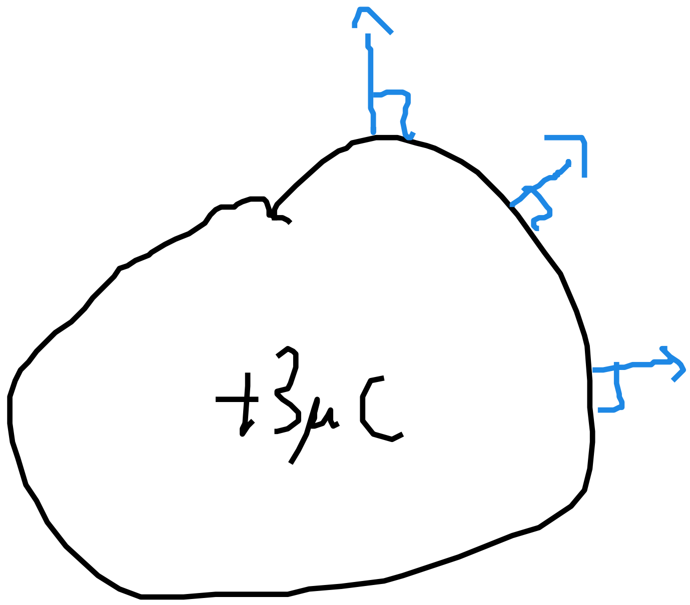
Conductors

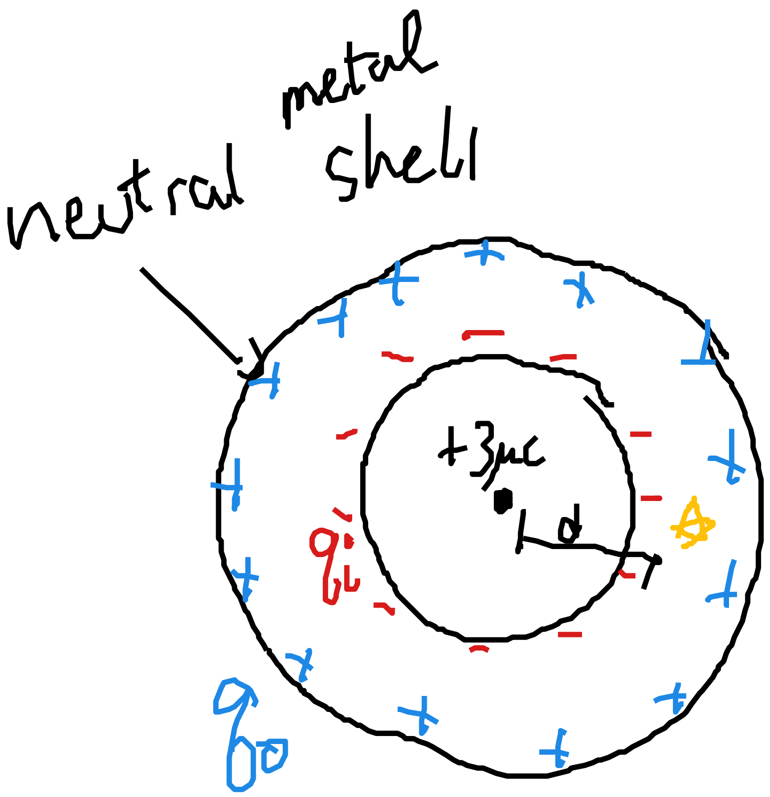
- $\vec{E}$ inside is zero if there is no flow of charge

- All excess charge on a conductor is at the surface



- Electric field just outside a conductor is $\perp$ to surface





$E_{☆} = 0$ inside metal

$$0 = E_{☆} = k\frac{(+3\mu C)}{d^2}\hat{out} + k\frac{q_i}{d^2}\hat{out}$$

$$= \frac{k}{d^2}\hat{out}\left[+3\mu C + q_i\right]$$

must be 0 : $q_i = -3\mu C$

Metal shell is neutral

$$q_o + q_i = 0$$

$$q_o - 3\mu C = 0$$

$$q_o = +3\mu C$$