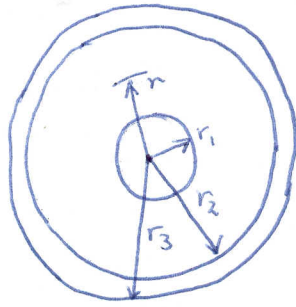


# 

1

(a)



$$r_1 = 5 \text{ mm}$$

$$r_2 = 5 + 10 = 15 \text{ mm}$$

$$r_3 = 15 + 1 = 16 \text{ mm}$$

$$\epsilon_r = 4.5$$

$$E = \left\{ \frac{V}{\ln(r_2/r_1)} \right\} \frac{1}{r} = \frac{k}{r} \quad \parallel \quad \underline{E = \frac{k}{r}}$$

$$D = \epsilon E = \epsilon_r \epsilon_0 E = \frac{k_1}{r} \quad \parallel \quad \underline{D = \frac{k_1}{r}}$$

$$V = - \int E dr = - \int \frac{k}{r} dr$$

$$V = -k \ln r + C$$

$$\parallel \quad \underline{V = C - k \ln r}$$

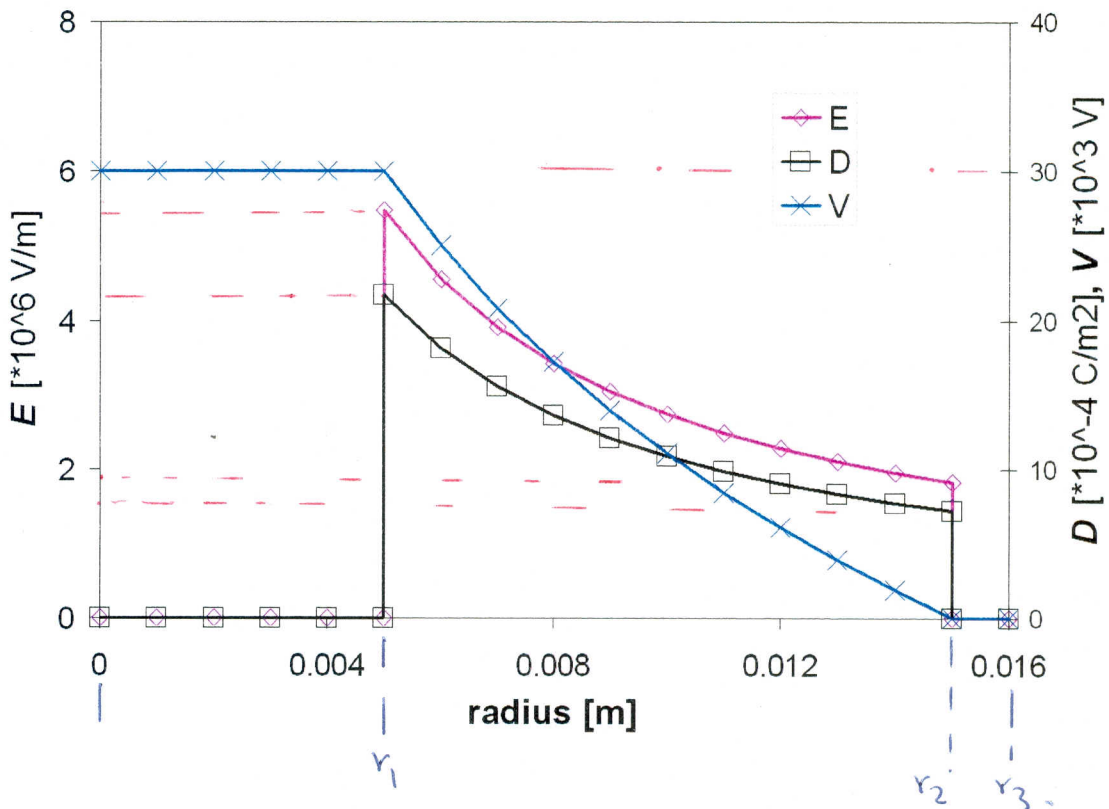
$$C = V + k \ln r$$

$$\text{at } r = r_1 = 5 \text{ mm}; V = 30 \text{ kV}$$

$$C = -114682$$

$$; k = 27307.18$$

$$V =$$



(b)  $l = 5 \text{ km}$

$$(i) C = \frac{2\pi l \epsilon_0 \epsilon_r}{\ln(r_2/r_1)} = \frac{2\pi \times 5 \times 10^3 \times 4.5 \times 8.85 \times 10^{-12}}{\ln(15/5)} \\ = 1.14 \times 10^{-6} \text{ F} = \underline{1.14 \mu\text{F}}$$

(ii)  $W = \frac{1}{2} CV^2 = \frac{1}{2} \times 1.14 \times 10^{-6} \times (30 \times 10^3)^2 = \underline{513 \text{ J}}$

(c)  $E_{\text{max}} = \frac{V_m}{r_1 \ln(r_2/r_1)} = \frac{\sqrt{2} V_{\text{rms}}}{r_1 \ln(r_2/r_1)}$

$$V_{\text{rms}} = \frac{r_1 \ln(r_2/r_1) E_{\text{max}}}{\sqrt{2}} = \frac{5 \times 10^{-3} \ln 3 \times 10^7}{\sqrt{2} \times 2} = \frac{19,421}{\sqrt{2}} = \underline{13,750 \text{ V}} \\ = \underline{13.75 \text{ kV}}$$

2.



$r_1 = 0.05 \text{ m}$

$r_2 = 0.4 \text{ m}$

$L = 0.5$

$V = 240 \text{ V}$

$P_1 = 8 \text{ kW} ; P_2 = 10 \text{ kW}$

$$P_1 = \frac{V^2}{R} \rightarrow R_1 = \frac{V^2}{P_1} = \frac{240^2}{8 \times 10^3} = 7.2 \Omega$$

$$I_1 = \frac{V}{R_1} = \frac{240}{7.2} = 33.3 \text{ A}$$

$$V = \frac{I_1}{2\pi l \sigma} \ln r_2/r_1$$

$$\sigma_1 = \frac{I_1 \ln r_2/r_1}{2\pi l V} = \frac{33.3 \ln(0.4/0.05)}{2\pi \times 0.5 \times 240} = 0.092 \text{ } \Omega^{-1}\text{m}$$

$$P_2 = \frac{240^2}{10 \times 10^3} = 5.76 \Omega ; I_2 = \frac{240}{5.76} = 41.7 \text{ A}$$

$$\sigma_2 = \frac{41.7 \ln(8)}{2\pi \times 0.5 \times 240} = 0.115$$

$$\% \text{ change} = \frac{(0.115 - 0.092)}{0.092} \times 100\% = \underline{25\%}$$

3. (a)  $A = 10^4 \text{ mm}^2$  ;  $B = 0.5 \text{ T}$

$$\text{"Force"} = \frac{1}{2} B A H = \frac{1}{2} \frac{B^2}{\mu} A = \frac{1}{2} \frac{(0.5)^2}{4\pi \times 10^{-7}} \times 10^4 \times 10^{-6} = \underline{995 \text{ N}}$$

$$W = \frac{1}{2} B H = \frac{1}{2} \frac{B^2}{\mu} = \frac{1}{2} \frac{0.5^2}{4\pi \times 10^{-7}} = \underline{99472 \text{ J/m}^3}$$

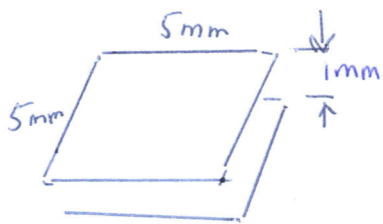
(b) if  $l = 10 \text{ mm}$ ,  $B = \text{same}$ , Force = 995 N, no change!

(c)  $B = \frac{1}{2} \times 0.5 = 0.25 \text{ T}$ ,

$$\text{"Force"} = \frac{1}{2} \frac{B_{\text{new}}^2}{\mu} = \frac{1}{2} \frac{0.25^2}{4\pi \times 10^{-7}} = \underline{248.75 \text{ N}}$$

ie  $\frac{1}{4}$  of OLD.

4.



$$E = \frac{V}{l} = \frac{1000}{1 \times 10^{-3}} = 1 \text{ MV/m}$$

$$P = \frac{1}{2} D E = \frac{1}{2} \epsilon E^2 = \frac{1}{2} \times 3 \times 8.85 \times 10^{-12} \times (10^6)^2 = \underline{13.3 \text{ N/m}^2}$$

$$\text{Force} = P \cdot A = 13.3 \times (0.05)^2 = \underline{0.033 \text{ N}}$$

5.

$$(a) W = \frac{1}{2} D E = \frac{1}{2} \epsilon E^2 = \frac{1}{2} \times 1 \times 8.85 \times 10^{-12} \times (0.8 \times (3 \times 10^6))^2 = \underline{25.5 \text{ J/m}^3}$$

$$(b) W = \frac{1}{2} \epsilon E^2 = \frac{1}{2} \times 8.85 \times 10^{-12} \times 4 \times (1.5 \times 10^7)^2 = \underline{3982.5 \text{ J/m}^3}$$

$$(c) W = \frac{1}{2} B H = \frac{1}{2} \frac{B^2}{\mu} = \frac{1}{2} \times \frac{1.4^2}{1000 \times 4\pi \times 10^{-7}} = \underline{780 \text{ J/m}^3}$$