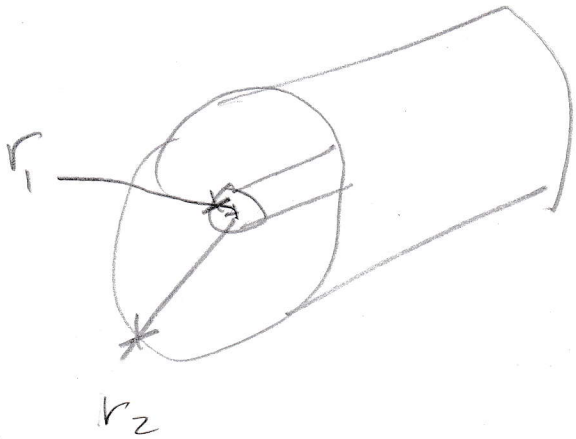
Homework 25.41

A coaxial cable used in a transmission line has an inner radius of 0.10 mm and an outer radius of 0.60 mm. Calculate the capacitance per meter for the cable. Assume that the space between the conductors is filled with polystyrene.

$$\Phi = \oint E \cdot dA = E_r L 2\pi r = \frac{\lambda L}{\epsilon_0}$$



$$E = \frac{\lambda}{2\pi\epsilon_0 r}$$

$$V = \frac{\lambda}{2\pi\epsilon_0} \ln\left(\frac{r_2}{r_1}\right)$$

$$= \frac{\lambda}{2\pi\epsilon_0} \ln(6)$$

$$C_0 = \frac{Q}{V}$$

$$\frac{C_0}{L} = \frac{Q/L}{V} = \frac{\lambda}{V} = \frac{2\pi\epsilon_0}{\ln(6)} = 31.0 \times 10^{-12}\ \text{F}$$

Add the dielectric

$$\frac{C}{L} = \kappa \frac{C_0}{L} = 2.6 \times 31 \times 10^{-12}$$

$$\frac{C}{L} = 80.7 \times 10^{-12} = \underline{\underline{81\ \text{pF}}}$$

Homework 25.45

A certain parallel-plate capacitor is filled with a dielectric for which $k = 5.5$. The area of each plate is 0.034 m^2, and the plates are separated by 2.0 mm.. The capacitor will fail (short out and burn up) if the electric field between the plates exceeds 200 kN/C. What is the maximum energy that can be stored in the capacitor?

$V = Ed$

$V_{max} = E_{max} d = 200 \times 10^{3} \times 2 \times 10^{-3} = 400V$

$C = \kappa C_0$

$W_{MAX} = \frac{1}{2} C V_{MAX}^2$

$C = \kappa \epsilon_0 \frac{A}{d} = 5.5 \times 8.854 \times 10^{-12} \left(\frac{0.034}{.002}\right)$

$W = \frac{1}{2}\left[5.5 \times 8.854 \times 10^{-12} \left(\frac{0.034}{.002}\right)(400)^2\right]$

$W = 66 mJ$

Homework 26.1

During the 4.0 min a 5.0 A current is setup in a wire, how many (a) coulombs and (b) electrons pass through any cross section of the wire's width?

$$\Delta t = 4 \times 60 = 240 \text{ sec}$$

$$i = \frac{\Delta Q}{\Delta t}$$

$$\Delta Q = i \Delta t = 5 \times 240 = 1200$$

a) $\Delta Q = 1.20 \text{ kC}$

$$\Delta Q = Ne$$

$$N = \frac{\Delta Q}{e} = \frac{1.2 \times 10^{3}}{1.6 \times 10^{-19}} = 0.75 \times 10^{22}$$

b) $N = 7.5 \times 10^{21}$

Homework 26.7

The fuse in an electric circuit is a wire that is designed to melt, and thereby open the circuit, if the current exceeds a predetermined value. Suppose that the material to be used in a fuse melts when then the current density rises to 440 A/cm^2. What diameter of cylindrical wire should be used to make a fuse that will limit current to 0.50 A?

$I = JA$

$A = \pi R^2$

$J = 440\ A/cm^2 * \frac{10^4\ cm^2}{m^2}$

$I = J\pi R^2$

$= 4.4 \times 10^6\ A/m^2$

$R = \sqrt{\frac{I}{J\pi}}$

$R = \sqrt{\frac{0.5}{4.4 \times 10^6\ \pi}} = 0.19 \times 10^{-3}\ m$

$D = 2R = 0.38\ mm$

Homework 26.41

A 120 V potential is applied to a space heater whose resistance is 14 ohms when hot. (a) At what rate is electrical energy transfered to thermal energy? (b) What is the cost for 5 h at US$0.05/kW*h?

$1\ \text{Watt} = 1\ \frac{\text{Joule}}{\text{Sec}}$

$P = \frac{dU}{dt}$

$= \frac{V^2}{R} = \frac{(120)^2}{14} = 1{,}028\ \text{Watts}$

a) $P = 1.03\ \text{KW}$

b) For $t = 5\text{h}$

$\text{KW}\cdot\text{h} = 1\ \text{KW} \cdot 5\text{h} = 5\ \text{KW}\cdot\text{h}$

$5\ \text{KW}\cdot\text{h} * 0.05\ \$/\text{KW}\cdot\text{h} = 0{,}25\ \$$

Cost = 25¢