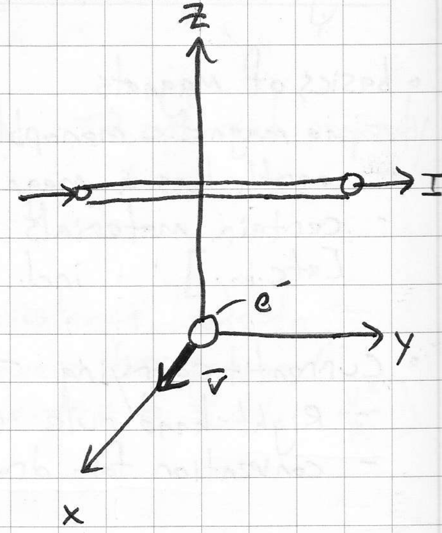
2/26/13

(Giordano P20.17)

ex Electron passes near a current-carrying wire laying in y-z plane. Electron moves along +x-axis. What is the force on the electron due to the wire's magnetic field?



- $\bar{B}_{wire}$ points along $-x$-axis where electron is

- $\bar{F}_m = q(\bar{v} \times \bar{B})$ where $q = -e$

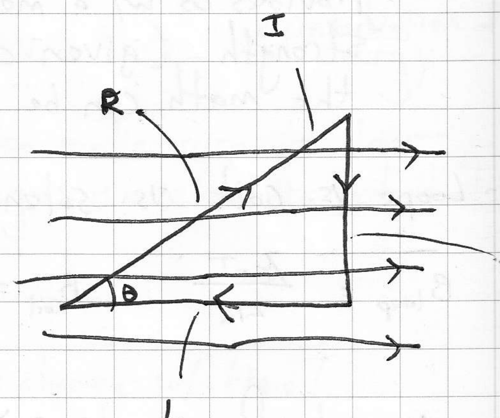
  but since $\bar{v} \times \bar{B} = 0$ (since they are parallel to one andther), the force is zero

- However, once the electron moves off the y-z plane, there will be a non-zero component of $\bar{v} \times \bar{B}$ and the electron will start feel a force

ex (Giordano P20.52)

length of wire

$F_{wire} = ILB\sin\theta$



$$\bar{F}_{total} = \sum_i \bar{F}_i$$

$$= \bar{F}_L + \bar{F}_R + \bar{F}_H$$

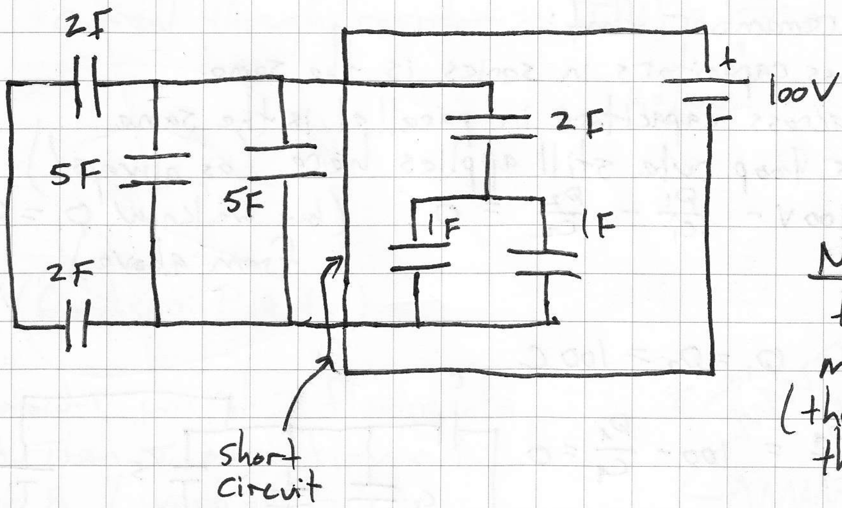
$$= 0 - IB\left(\frac{L}{\cos\theta}\right)\sin\theta + IBL\tan\theta$$

$$= 0 \quad \text{(no net force, regarless of } \theta\text{!)}$$

- Note that sign diff. arises because F_R is into the page and F_H is out of the page

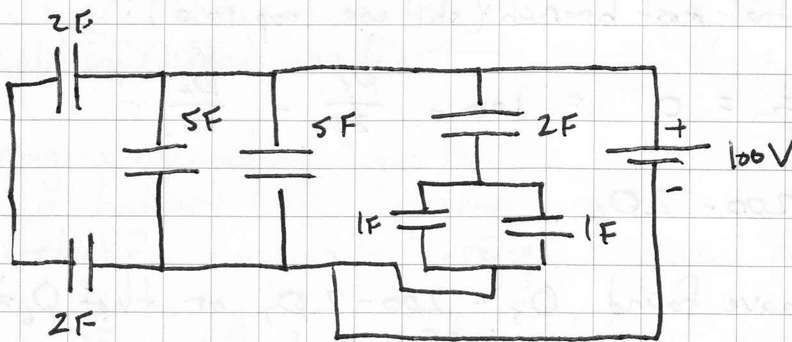
12/26/13

ex (Giordano P19.100)

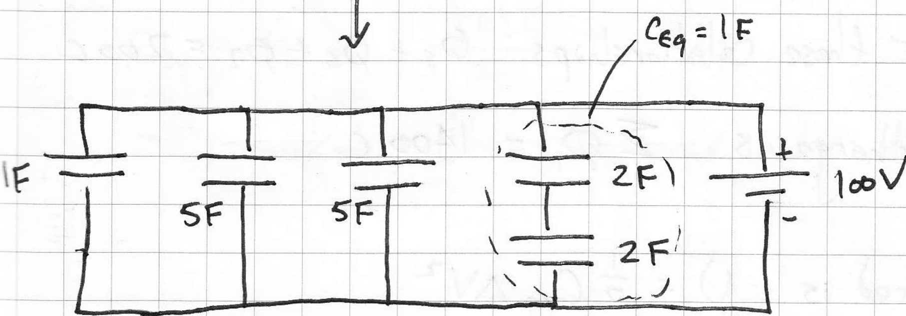


NOTE: As shown in the text, the problem makes no sense! (there is a short across the battery)

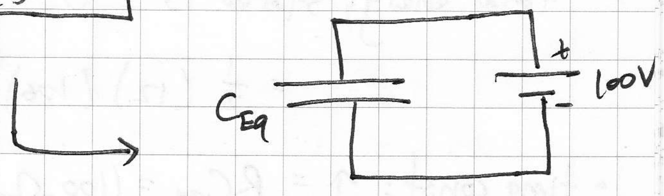
More realistic version (that doesn't kill the battery)



Strategy
Break down the various branches into smaller and smaller pieces



$C_{Eq} = 12F$



2/26/13 (cont.)

(19.100 cont)

To get the charge, remember that:

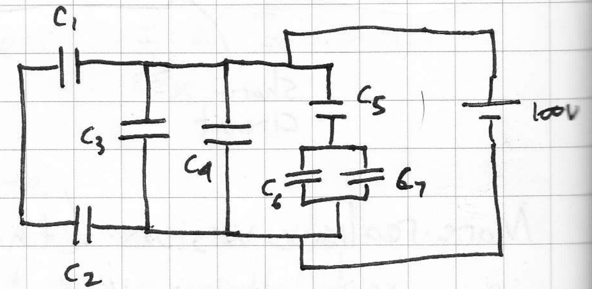
- charge across capacitors in series is the same
- potential across capacitors in parallel is the same
- Kirchoff's loop rule still applies here (as always!)

e.g. $100\,V - \frac{Q_1}{C_1} - \frac{Q_2}{C_2} = 0$ (but we know $Q_1 = Q_2$ from above)

since $C_1 = C_2 = 2F$, $Q_1 = Q_2 = 100\,C$

similarly: $100 - \frac{Q_3}{C_3} = 100 - \frac{Q_4}{C_4} = 0$

$C_3 = C_4 = 5F \rightarrow Q_3 = Q_4 = 500\,C$



a bit tricky for the central-most branch: (still use loop rule):

$$100 - \frac{Q_5}{C_5} - \frac{Q_6}{C_6} = 0 = 100 - \frac{Q_5}{2F} - \frac{Q_6}{1F}$$

$$\rightarrow Q_5 = 200 - 2Q_6$$

we similarly could have found $Q_5 = 200 - 2Q_7$ or that $Q_6 = Q_7$ using different loops

adding together these relationships: $Q_5 + Q_6 + Q_7 = 200\,C$

thus the total charge is $\sum_i Q_i = 1400\,C$

- total energy stored is $U = \frac{1}{2} C_{eq} \Delta V^2$

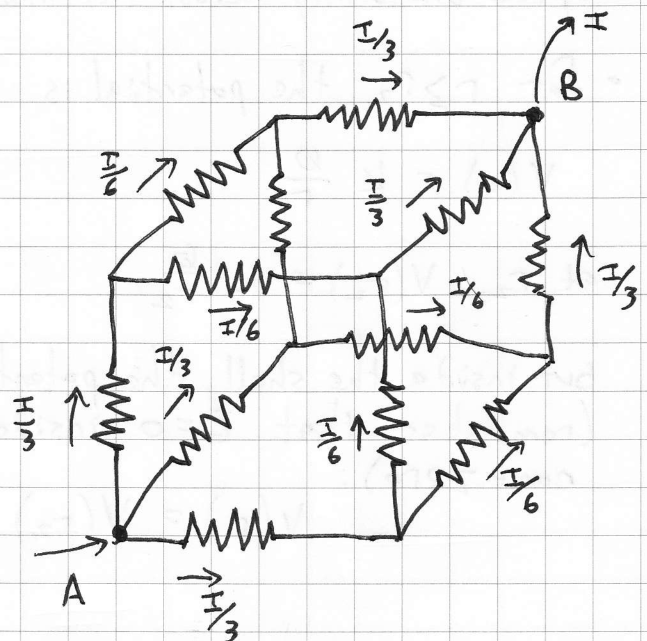
$$= \frac{1}{2}(12)(100)^2 = 6 \times 10^4\,J$$

- time const: $\tau = RC_{eq} = (100\,\Omega)(12\,F) = 1.2 \times 10^3\,s$ (very long!)

(19.100 cont.)

current through resistor: $I(t) = \frac{\overset{\mathcal{E}=100\text{V}}{\mathcal{E}}}{\underset{R=100\,\Omega}{R}} e^{-t/\tau} = e^{-t/1200}\ \text{A}$

$\boxed{\text{ex}}$ (Giordano P19.46)



- consider current I flowing into A. Then I must flow out at B (junction rule)
- since all resistors are the same, there is a symmetry in how the current gets split up / added together
- imagine connecting A and B to a battery ($\mathcal{E}$). Applying Kirchoff's loop rule through a given path:

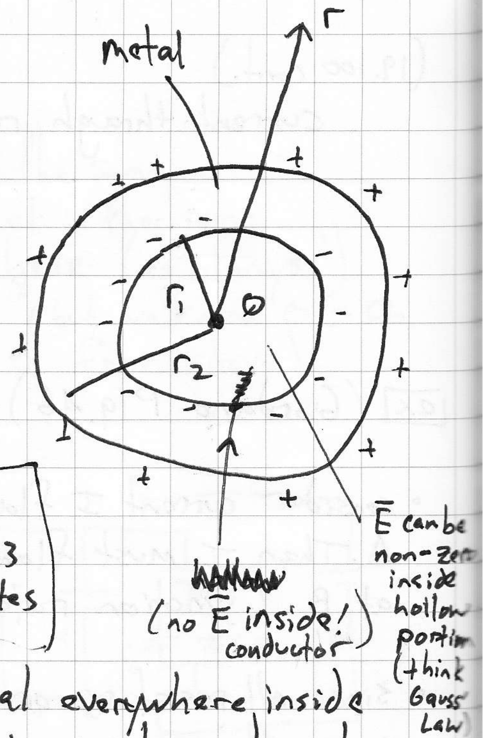
$$\mathcal{E} - \left(\frac{I}{3}\right)R - \left(\frac{I}{6}\right)R - \left(\frac{I}{3}\right)R = 0 \quad \rightarrow \quad \mathcal{E} = I\left(\frac{5}{6}R\right)$$

$$R_{eq} = \frac{\mathcal{E}}{I} = \frac{\left(\frac{5}{6}R\right)I}{I} = \frac{5}{6}R$$

→ remarkably this resistance is less than a single resistor!

2/26/13

ex (Giordano P18.30)



- since $\bar{E}=0$ inside the inner shell ($r<r_1$) there must be $-Q$ excess charge spread uniformly across the inner surface
- for $r \geq r_2$, the potential is

$$V(r) = k\frac{Q}{r}$$

for additional ref. see 'fig. 27.33 from 1/22/13 notes

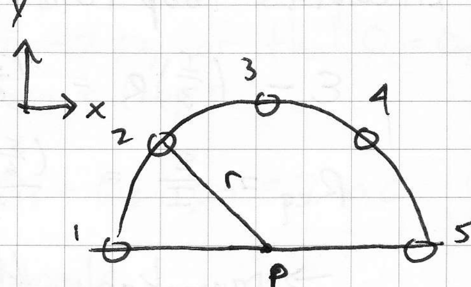
at r_2, $V(r_2) = k\frac{Q}{r_2}$

but inside the shell, the potential is equal everywhere inside (remember that $\bar{E}=0$ inside, but V is const. and can be non-zero):

$$V(r_1) = V(r_2) \longrightarrow V(r_1) = k\frac{Q}{r_2}$$

$\therefore$

ex (Giordano P17.48)



$$\bar{E} = \sum_i E_i = \bar{E}_2 + \bar{E}_3 + \bar{E}_4$$

$$(\bar{E}_1 + \bar{E}_5 = 0)$$

$$= (\cos 45)\, k\frac{Q}{r^2}(-\hat{y}) + k\frac{Q}{r^2}(-\hat{y}) + (\cos 45)\, k\frac{Q}{r^2}(-\hat{y})$$

$$= (1+\sqrt{2})\, k\frac{Q}{r^2}(-\hat{y})$$

NOTE: Vector components along $\hat{x}$ cancel out (only left w/ components pointing along $-\hat{y}$ (assuming $Q>0$)

$\therefore$