Fundamentals of Electricity

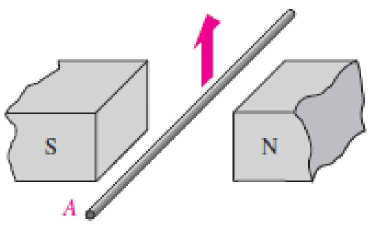
Fall 2016

Assignment #7

You have to provide the **<u>detailed solution</u>** for each problem **<u>AND</u>** fill the **<u>answer table</u>** on last page

<u>Problem 1:</u>

A 20 cm long conductor is moving upward between the poles of a magnet as shown in the following Figure. The pole faces are 8.5 cm^2 on each side and the flux is 1.24 mWb. The motion produces an induced voltage across the conductor of 44 mV. What is the speed of the conductor?



When a conductor is moved in a magnetic field, the induced voltage is given by the formula,

$v_{ind} = B_{\perp} l v$

Where,

$B_{\perp}$ is the magnetic flux density that is perpendicular to the moving conductor in teslas, and v is the velocity or speed of the conductor in m/s.

The flux density is given by,

$$B_{\perp} = \frac{\phi}{A}$$
$$= \frac{1.24 \times 10^{-3}\ \text{Wb}}{\left(8.5 \times 10^{-2}\ \text{m}^2\right)^2}$$
$$= 0.172\ \text{Wb/m}^2 \text{ or tesla}$$

Although the conductor is $20\ \text{cm}$ long, only $8.5\ \text{cm}$ is in the magnetic field. Thus the value of $l = 8.5\ \text{cm}$.

By substituting the known values in the induced voltage formula, we obtain the following:

$$\left(44\times10^{-3}\ \text{V}\right) = (0.172)\left(8.5\times10^{-2}\ \text{m}\right)v$$

$$v = \frac{44\times10^{-3}\ \text{V}}{(0.172)\left(8.5\times10^{-2}\ \text{m}\right)}$$

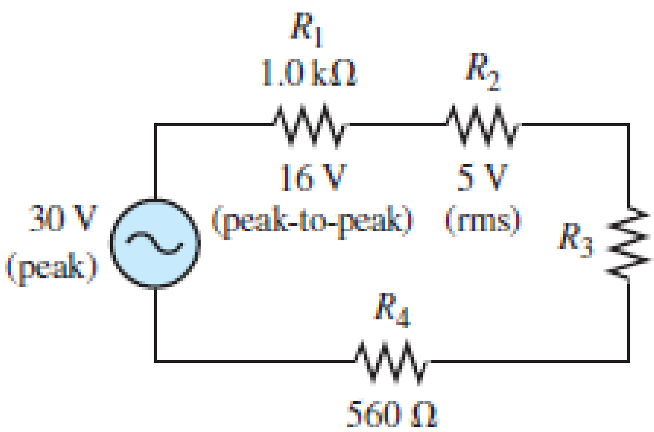
$$v = 3.01\ \text{m/s}$$

Thus the speed of the conductor is,

$$\boxed{v = 3.01\ \text{m/s}}$$

Problem 2:

Determine the rms voltage across R3 in the following figure.



We can find the rms current going through the loop by finding the curr
one of the resistors since it is a series circuit. So by applying Ohm's L

$$I = \frac{V_1}{R_1}$$
$$= \frac{5.66\ \text{V}}{1.0\ \text{k}\Omega}$$
$$I = 5.66\ \text{mA}$$

Again by applying Ohm's Law on R_4 , we get

$$V_4 = IR_4$$
$$= (5.66\ \text{mA})(560\ \Omega)$$
$$V_4 = 3.17\ \text{V}$$

By applying Kirchhoff's voltage law to the above circuit, we get

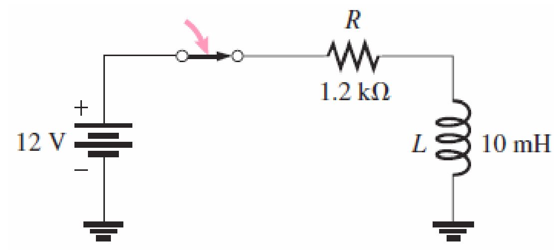
$$V_3 = V_s - V_1 - V_2 - V_4$$
$$= 21.21\ \text{V} - 5.66\ \text{V} - 5\ \text{V} - 3.17\ \text{V}$$
$$V_3 = 7.38\ \text{V}$$

Therefore rms voltage across R_3 is given by

$$\boxed{V_3 = 7.38\ \text{V}}$$

Problem 3:

From this figure and given the following general formula $i = I_F + (I_i - I_F)e^{-\frac{t}{\tau}}$, define I_i, I_F, τ, and i at 20 µs.



$I_i = \underline{0A}$ $(t = 0s)$

$I_F = \frac{V_S}{R}$ $(t = \infty)$ -> the inductance is considered as a conducting wire, no resistance -> then Ohm's Law.

$I_F = \frac{12}{1{,}2\,10^3} = 0{,}01 = \underline{10mA}$.

$i(t) = I_F + (0 - I_F)e^{-t/\tau}$

$i(t) = I_F - I_F e^{-t/\tau} = I_F(1 - e^{-t/\tau})$

with $\tau = \frac{L}{R} = \frac{10.10^{-3}}{1{,}2\,10^3} = 8{,}3\,10^{-6}s. = \underline{8{,}3\mu s}$

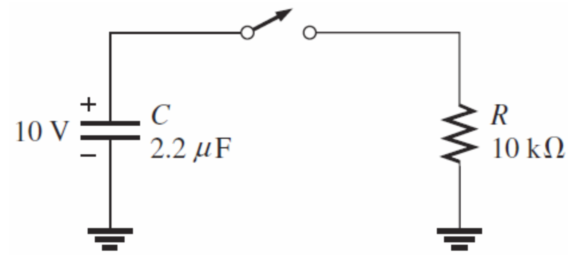
at $t = 20\mu s$

$i(20\mu s) = 0{,}01\left(1 - e^{-\frac{20}{8{,}3}}\right) = 0{,}009 = \underline{9\,mA}$

We have an increase of current over time with a maximum of I_F. $i(20\mu s) < I_F$ is correct.

Problem 4:

From this figure and given the following general formula $v = V_F + (V_i - V_F)e^{-\frac{t}{\tau}}$, define V_i, V_F, τ, and v at 45 ms.



$V_I = \underline{10\,V}$ $(t = 0\,s)$

$V_F = 0\,V$ $(t = \infty)$ -> the capacitor is completely discharged.

$\tau = RC = 10.10^3 \times 2{,}2\,10^{-6} = 22.\,10^{-3}\,s = \underline{22\,ms}$.

$v(t) = 0 + (V_I - 0)e^{-t/\tau}$

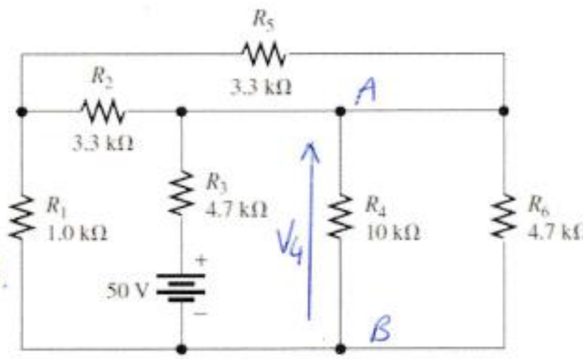
$= V_I e^{-t/\tau}$

$v(45ms) = 10\,e^{-\frac{45}{22}} = 1{,}3\,V$

We have a discharge of the voltage from the capacitor.
with 0V at ∞. $v(45\,ms) < V_I$ is correct.
$v(45\,ms) > V_F$ is correct.

Problem 5:

Using Thevenin's theorem, find the voltage across R4



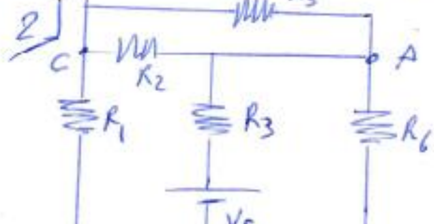
1- Removing R_4

2- Find the voltage between A & B.

3- Find the Thevenin Resistance

4- Find V_4.

2]



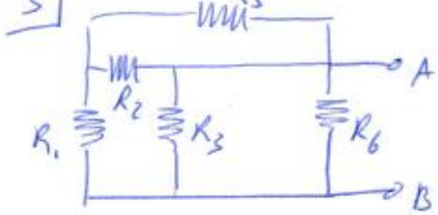
R_5 is // to R_2.
They share same nodes
Then they are in Series with R_1
=> all // to R_6.

=>

$R_6 // (R_1 + R_2 // R_5) = 1,7\,k\Omega$.

$$\Rightarrow V_{AB} = V_{TH} = \frac{R_{AB}}{R_3 + R_{AB}} \times V_S = \frac{1,7}{6,4} \times 50 = 13,3\ V$$

3]

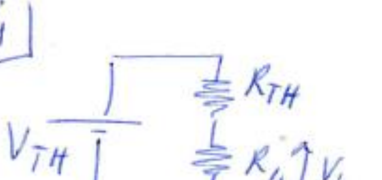


R_{TH} can be found when we shortcircuiting V_S

$$R_{TH} = \underbrace{R_6 // R_3}_{2,35} // \Big[\underbrace{R_1 + R_2 // R_5}_{=2,65}\Big]$$

$$R_{TH} = 2,35 // 2,65 = \underline{1,2455\ k\Omega}.$$

4]



$$V_4 = \frac{R_4}{R_4 + R_{TH}} \times V_{TH} = \frac{10}{10 + 1,25} \times 13,3V = \boxed{11,8V}$$

ANSWERS

Problem 1	$Speed$	**3.01 m/s**
Problem 2	V_{rms}	**7.38 V**
Problem 3	I_i= I_F= τ= $i(20\mu s)$=	**0 A** **10 mA** **8.3 μs** **9 mA**
Problem 4	V_i= V_F= τ= $v(45ms)$=	**10 V** **0 V** **22 ms** **1.3 V**
Problem 5	$V4 =$	**11.7 or 11.8 V**