Midterm exam answer key

Version 1

S1a) Electric current: directed flow of charge through a conductor

S1b)

V: source of voltage: it creates the difference of potential (voltage) at the source output

r: internal resistance: models the drop in output voltage when the current increases (or dependence of output voltage of current)

S1c) True power represents the power dissipated as heat by the resistor

S1d) Volt-Ampere-reactive (VAR)

S1e) $G = \frac{I}{V}$; G = conductance, I = current, V = voltage

S2a)

S2b) We need to determine the current I first

$I = \frac{V}{R_1 + R_2}$ $\quad I = \frac{10V}{10 \cdot 10^3 + 15 \cdot 10^3}$ $\quad I = 0.4\ mA$

$V_{R_1} = I \cdot R_1 \Rightarrow V_{R_1} = 0.4 \times 10^{-3} \times 10 \cdot 10^3$ $\quad V_{R_1} = 4V$

$V_{R_2} = I \cdot R_2$ $\quad V_{R_2} = 0.4 \times 10^{-3} \times 15 \times 10^3$

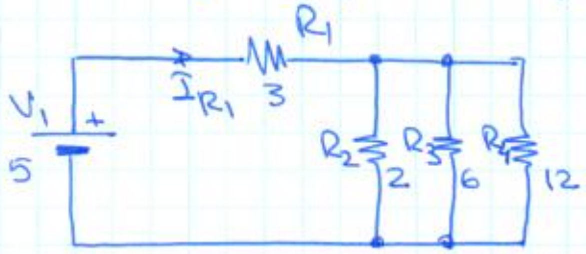
OR $\Rightarrow$ OR $\quad V_{R_2} = 6V$

$V_{R_2} = V - V_{R_1}$ $\quad V_{R_2} = 10 - 4$

S2c) Since the resistors are connected in series,

$I_{R_1} = I_{R_2} = I \qquad I_{R_1} = 0.4\ mA \qquad I_{R_2} = 0.4\ mA$

S3 ab) Upon inspecting the schematic, R_2, R_3 and R_4 are connected in parallel.



Let $R_p = R_2 \| R_3 \| R_4$

$$R_p = \frac{1}{\frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}}$$

$$I_{R_1} = \frac{V_1}{R_1 + \frac{1}{\frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}}} \qquad I_{R_1} = \frac{5}{3 + \frac{1}{\frac{1}{2} + \frac{1}{6} + \frac{1}{12}}} =$$

$$= \frac{5}{3 + \frac{1}{\frac{6}{12} + \frac{2}{12} + \frac{1}{12}}} = \frac{5}{3 + \frac{12^4}{9_3}} = \frac{5}{\frac{13}{3}} = \frac{15}{13}\ A$$

$I_{R_1} = 1.154\ A$

$V_{R_1} = R_1 \cdot I_{R_1} \qquad V_{R_1} = 3 * \frac{15}{13} \qquad V_{R_1} = \frac{45}{13} V = 3.46\ V$

$V_{R_2} = V_{R_3} = V_{R_4} = V_1 - V_{R_1} \Rightarrow V_{R_2} = V_{R_3} = V_{R_4} = 1.54V$

$I_{R_2} = \frac{V_{R_2}}{R_2} \qquad I_{R_2} = 0.77\ A$

$I_{R_3} = \frac{V_{R_3}}{R_3} \qquad I_{R_3} = 0.257\ A$

$I_{R_4} = \frac{V_{R_4}}{R_4}$ or $I_{R_4} = I_{R_1} - I_{R_2} - I_{R_3} \qquad I_{R_4} = 0.128\ A$

S3c) Let R_2 resistance be x. The text tells us that the resistance is $x\,\Omega$ and the conductance is x (Siemens). Thus

$$x = \frac{1}{x} \quad \left(\text{because } G = \frac{1}{R} \text{ or } R = \frac{1}{G}\right) \Leftrightarrow$$

$\Leftrightarrow x^2 = 1 \Rightarrow x = \pm 1$. We only retain the positive value (resistance can't be negative in this context), so $\underline{R_2 = 1\,\Omega}$

We need to recalculate the current through R_1:

$$I_{R_1} = \frac{V_1}{R_1 + \frac{1}{\frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}}} \qquad I_{R_1} = \frac{5}{3 + \frac{1}{\frac{1}{1} + \frac{1}{6} + \frac{1}{12}}} =$$

$$= \frac{5}{3 + \frac{1}{\frac{12}{12} + \frac{2}{12} + \frac{1}{12}}} = \frac{5}{3 + \frac{12}{15}} = \frac{5}{\frac{57}{15}} = \frac{75}{57}\ \text{A}$$

$\underline{I_{R_1} = 1.3596\ \text{A}}$

$$\left.\begin{array}{l} V_{R_1} = R_1 \cdot I_{R_1} \\ V_{R_3} = V_1 - V_{R_1} \end{array}\right] \Rightarrow \left.\begin{array}{l} V_{R_3} = V_1 - R_1 \cdot I_{R_1} \\ P_{R_3} = \frac{V_{R_3}^2}{R_3} \end{array}\right] \Rightarrow$$

$$\Rightarrow P_{R_3} = \frac{(V_1 - R_1 \cdot I_{R_1})^2}{R_3} \qquad P_{R_3} = \frac{(5 - 3 \times 1.3596)^2}{6}$$

$$P_{R_3} = \underline{141.4\ \text{mW}}$$

S4)

L_i = initial inductance $L_i = \frac{\mu_m N^2 A}{l_i}$

L_f = final inductance $L_f = \frac{\mu_m N^2 A}{l_f}$

We're told that $L_f = 1.2 \times L_i$ ← 20% increase

$\frac{L_f}{L_i} = 1.2 \Leftrightarrow \frac{\mu_m N^2 A}{l_f} \cdot \frac{l_i}{\mu_m N^2 A} = 1.2 \Rightarrow$

$\Rightarrow l_f = \frac{l_i}{1.2} \Big| - l_i \Rightarrow l_f - l_i = l_i \left(\frac{1}{1.2} - 1\right)$

$l_i = 6 \times r$ (radius) given. $r = \frac{d}{2}$ (diameter) $d = 10 \cdot 10^{-2}$ m

$\Rightarrow l_f - l_i = 6 \times \frac{10 \times 10^{-2}}{2} \cdot \left(\frac{10}{12} - \frac{12}{12}\right)$

$l_f - l_i = 6 \cdot \frac{0.1}{2} \cdot \left(-\frac{2}{12}\right) = -0.05$ m

So the coil needs to be compressed w.r.t 5 cm to achieve a 20% increase in inductance.