INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES LYON

SCAN 1st - Year: 2017-2018

PHYSICS EXAM - **ELECTRODYNAMICS**

Friday, January, the 12th - Duration: 1h

- No documents allowed. No calculator allowed.
*- **The marks will account for the justifications**, the critical analysis of your results, as well as for the writing and the general clarity and cleanness of your documents.*
*- **Every non homogeneous result presented without any comment will lead to a penalty on your final grade.***

Assignment I: Transient circuit *(≈ 9 pts)*

For the circuit depicted in Figure 1, the switch **opens** at $t = 0$. We know that the switch was closed from $t = -\infty$.

1. Determine the evolution in time of the intensity $\boldsymbol{i_L(t)}$ of the current through the coil and of the voltage across the coil $\boldsymbol{v_L(t)}$ as a function of the components (E, L, R_1 and R_2). Do not forget to justify all the steps.

2. Check that your expressions of $i_L(t)$ and $v_L(t)$ are consistent with the behavior of the circuit when $t \to + \infty$.

3. Compute the amount of energy denoted $\Delta\varepsilon_L$ which has been stored in the coil from $t = 0$ to $t \to + \infty$. What can you deduce from this expression about the behavior of the coil during this time interval?

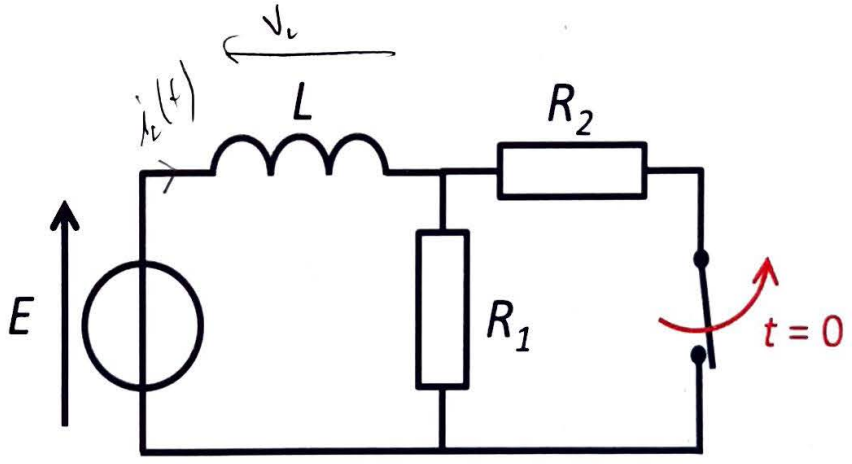

Figure 1

Assignment 2: AC circuit *(≈ 11 pts)*

We consider the circuit represented in Figure 2. It consists in an ideal voltage source of e.m.f. $e(t) = E_m \cos(\omega t)$ on branch (SA) and two branches (SCA) and (SNA) composed of identical elements: two identical resistors of resistance R and two identical dipoles of complex impedance $\underline{Z}$. The complex notation will be used throughout the whole assignment.

1. Express the current intensities in branches (SCA) and (SNA) and compare them.
2. Calculate the voltage differences $\underline{V_C - V_A}$ and $\underline{V_N - V_A}$. Deduce the voltage difference $\underline{u} = \underline{V_C - V_N}$ between points C and N as a function of R, $\underline{Z}$, and $\underline{e}$.

Let's now consider that $\underline{Z}$ is an ideal capacitor of capacitance C_0.

3. Based on the behavior of the circuit at very low and very high frequencies, towards which limits does the voltage $\underline{u}$ tend to at very low and very high frequencies?
4. Show that the transfer function can be written as in equation 1, and provide the expression of ω_0. What is its dimension?

$$\underline{H}(j\omega) = \frac{\underline{u}}{\underline{e}} = \frac{1 - j\frac{\omega}{\omega_0}}{1 + j\frac{\omega}{\omega_0}} \qquad \text{(equation 1)}$$

5. Calculate the modulus $G(\omega)$ and the phase $\phi(\omega)$ of $\underline{H}(j\omega)$.
6. Represent schematically the evolution of ϕ versus ω. Indicate all characteristic quantities on your graph.
7. Explain why this circuit can be qualified as "phase shifter"?

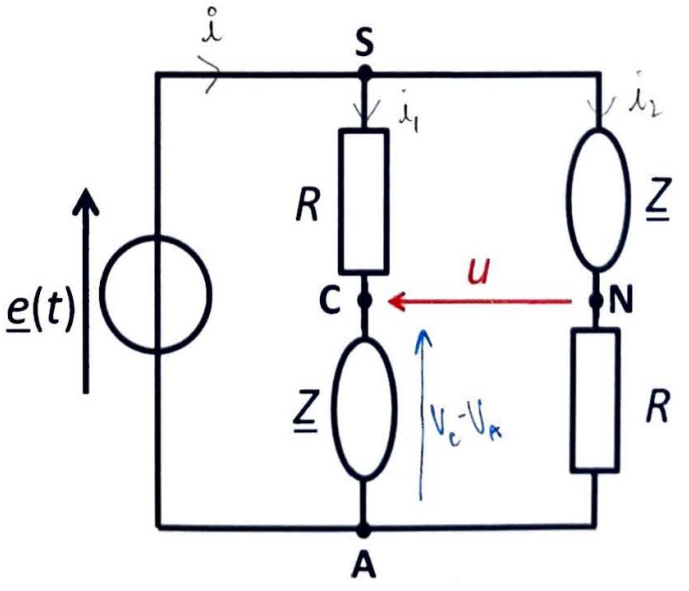

Figure 2