Physics exam 1 – Semester 2
March 31, 2023. Duration: 1h30

No document allowed. No mobile phone. Non-programmable calculator allowed. The proposed grading scale is only indicative.
The marks will account not only for the results, but also for the justifications, and the way you analyze the results. Moreover, any result must be given in its literal form involving only the data given in the text. It is also reminded that the general clarity and cleanness of your paper may also be taken into account.

Exercise 1: Unknown dipole

An unknown electric component is powered by an AC voltage source with a variable frequency f. The modulus of its impedance is measured and represented as a function of the frequency on Figure 1. This component is made of two dipoles among a resistor, a coil and a capacitor.
Propose a possible association of two dipoles that could correspond to this electric component. Your answer should be justified, and specify the dipoles connections (series or parallel) as well as their characteristics (resistance, capacitance and/or inductance).
Deduce the argument of this component's impedance at a frequency $f = 200$ Hz.

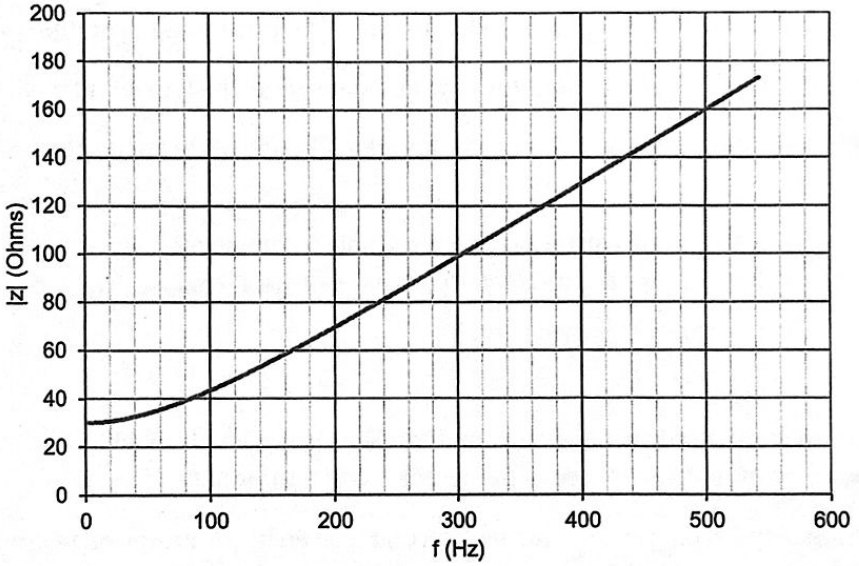

Figure 1: Modulus of the impedance of the unknown dipole as a function of the frequency.

Exercise 2

Let's consider the electrical circuit represented on figure 2 made of a sinusoidal voltage supply, frequency f, feeding in series an ohmic conductor of resistance R, a capacitor of capacitance C and a coil of inductance L.

Part 1 - AC analysis

Let $i(t) = I\cos(\omega t)$, with I the peak amplitude of the current crossing the circuit and $\omega = 2\pi f$ the angular frequency.

1. Choosing an appropriate phase reference, represent the complex voltage $\underline{u}(t)$ in a phasor diagram (we will assume that the modulus of the impedance of the capacitor is greater than that of the coil).

2. Find the expression of the real voltage $u(t)$ at the terminals of the generator according to the data of the problem.

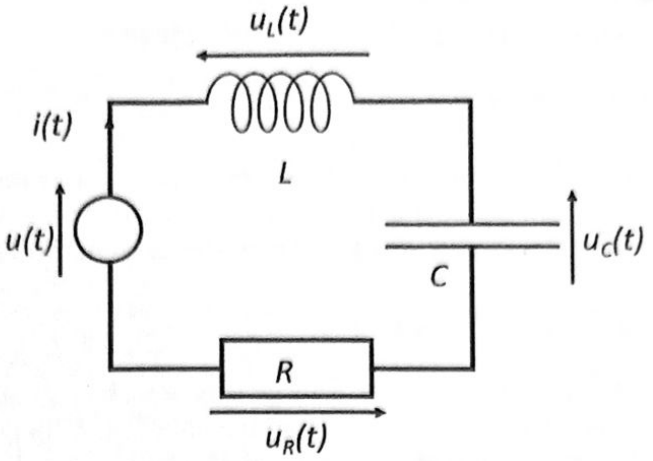

Figure 2: Electric circuit.

Part 2 - filter analysis

1. Determine the expression of the complex transfer function $\underline{H}$ representing the ratio $\underline{H} = \underline{u}_C / \underline{u}$.
2. Study the asymptotic behavior of the modulus of $\underline{H}$ and determine the type of filter we have.
3. Represent qualitatively the evolution the transfer function's phase (indicate particular values if necessary).
4. Still considering $u(t)$ as the input voltage having a variable frequency (ω), what type of filter would you have taking the output voltage across R? quick analysis when $\omega \to 0$ etc

Exercise 3

An electric motor behaves as an ohmic conductor of resistance r and an ideal coil of inductance L in series. This motor is powered by an AC voltage source of frequency f and amplitude E.

1. Give the expression of the average power (active power) received by the motor, expressed as a function of the provided data.
2. We add a capacitor in series with the coil and resistor. Determine the new amplitude of the current I', and indicate how we can maximize the power received by the motor.