End-of-term exam

EE1C1 “Linear Circuits A”

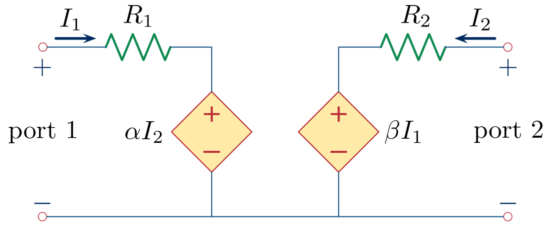
- This exam consists of 4 exercises.
- Each exercise accounts for **10 points**; the total number of points to be obtained is **40**. The exam grade is obtained by dividing the total number of points by 4, rescaling linearly the result to the 1-10 scale and rounding off to 1 decimal.
- **Each exercise must be solved on a separate double-sheet.** Writing more solutions on the same sheet may result in only one of the solutions being graded!
- Indicate your name and study number on **each** submitted sheet. **You must hand in (blank) signed sheets even for the exercises that you do not handle.**
- Students benefitting of the “Extra Time” (ET) rule are entitled to a 20 minutes extension of their exam provided they produce the relevant supporting document.
- Should any question not be completely clear, you are allowed to ask the instructors in the exam hall; the answer will be confined to rephrasing the text of the exercise such that to make it more intelligible.
- Should a part of an exercise depend on a previous result, mistakes made at a previous step will only be penalised once.
- Give your solution as completely as possible and never state numerical results without indicating how you derived them. **Simply stating numerical results will yield no points.**
- **When requested, fill in the measure units for all calculated quantities.** This holds for intermediate results but definitely for the final ones.
- Write clearly and avoid messy solutions. Should errors occur in your solution, cross the erroneous part out and give clear indications on where the correct solution resumes.
- For this exam you are allowed to use:
    1. a simple calculator – programmable and graphic calculators are explicitly prohibited;
    2. a handwritten, double-sided A4 sheet with formulas.
- The text of this exam is offered only in English. Inasmuch as possible, instructors will assist you with the Dutch translation of formulations that you may have difficulties to understand.

The Linear Circuits team wishes you a lot of success!

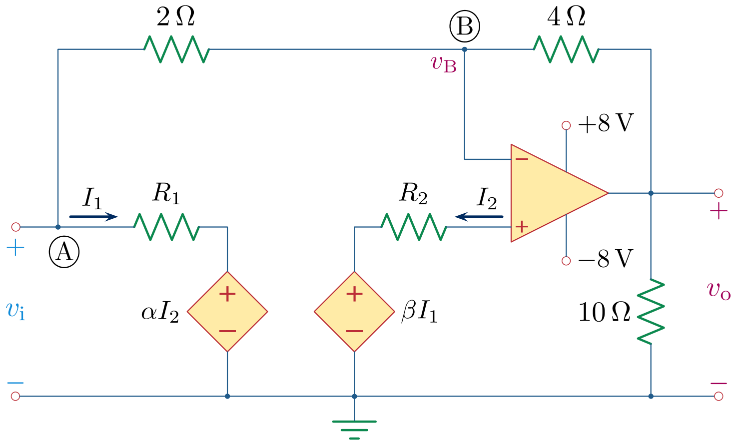
- Take a new double-sheet -

Exercise 1

Any linear and resistive two-ports component can be modelled using the circuit below:



Consider that such a component is connected to an ideal op-amp as shown below:



a) Calculate the ratio of voltage at node B over the input voltage (v_B/v_i). State your answer in terms of R_1, R_2, α and β. (3 points)

Hint: In this subpoint, and in the following ones, some of the parameters R_1, R_2, α and β may be missing in the requested expressions.

b) Calculate the gain v_o/v_i of this op-amp circuit. State your answer in terms of R_1, R_2, α and β. (3 points)

c) What conditions are required to achieve a gain smaller than -1? State your answer in terms of R_1, R_2, α and β. (2 points)

d) Assume that the input voltage is $v_i = 2\,V$. Assuming that a symmetric voltage source supplies power to the op-amp at the voltages ±8 V, what conditions are required to prevent this op-amp from saturating (op-amp stays in the linear region of operation) while still ensuring a gain smaller than -1? State your answer in terms of R_1, R_2, α and β (2 points)

Indicate the measure units for all calculated quantities. Show all steps in your reasoning and never give numerical results without justification.

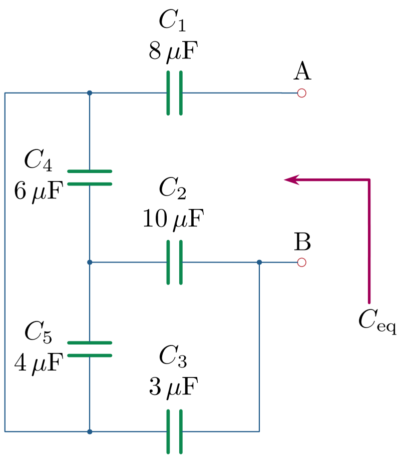
- Take a new double-sheet -

Exercise 2

If the current through a 20 mH inductor is given by $i(t) = 2e^{-2t} + 2t^2$ A , then:

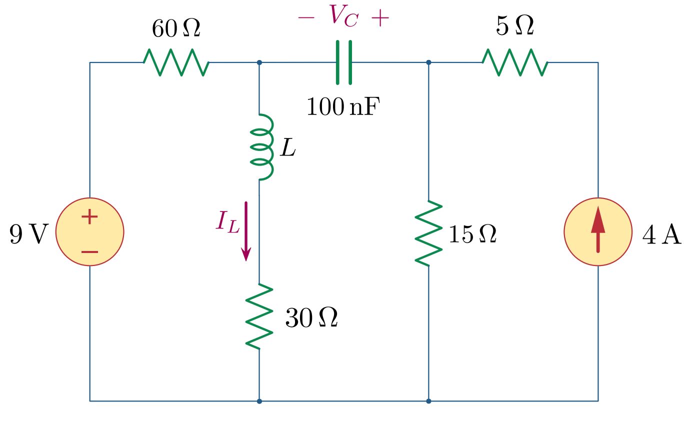
a) Calculate the voltage across the inductor at $t = 1$s. (2 points)

Now consider the circuit in the figure below:



b) Calculate the equivalent capacitance C_{eq} at the terminal A–B. (2 points)

Finally, consider now the following circuit under steady-state conditions:



c) Calculate the current I_L through the inductor and the voltage V_C across the capacitor. (3 points)

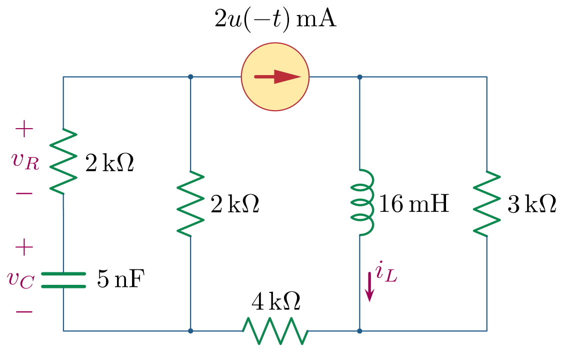
d) Calculate the value of the inductance L so that the energy stored in the capacitor is equal to ***three times*** the energy stored in the inductor. (3 points)

Indicate the measure units for all calculated quantities. Show all steps in your reasoning and never give numerical results without justification.

- Take a new double-sheet -

Exercise 3

Consider the circuit in the figure below:



a) Calculate $v_C(0^+)$ and $i_L(0^+)$. (2 points)

b) Redraw the circuit that applies for $t > 0$. (1 point)

c) Calculate $v_R(0^+)$. (2 points)

d) Calculate $v_R(t)$ and $i_L(t)$ for $t \to \infty$. (1 point)

e) Determine the expression of $i_L(t)$ for $t > 0$. (2 points)

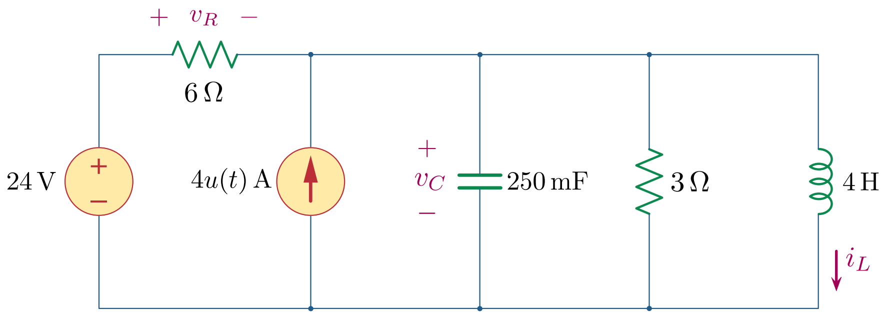
f) Determine the expression of $v_R(t)$ for $t > 0$. (2 points)

Indicate the measure units for all calculated quantities. Show all steps in your reasoning and never give numerical results without justification.

- Take a new double-sheet -

Exercise 4

Consider the circuit in the figure below:



a) Calculate $i_L(0^+)$, $v_C(0^+)$, $v_R(0^+)$, and $i_L(\infty)$, $v_C(\infty)$, $v_R(\infty)$. (3 points)

b) Calculate $\frac{\mathrm{d}v_C(0^+)}{\mathrm{d}t}$, $\frac{\mathrm{d}i_L(0^+)}{\mathrm{d}t}$, $\frac{\mathrm{d}v_R(0^+)}{\mathrm{d}t}$. (3 points)

c) Calculate $i_L(t)$ for $t > 0$. (4 points)

Indicate the measure units for all calculated quantities. Show all steps in your reasoning and never give numerical results without justification.