End-of-term exam

EE1C1 "Linear Circuits A"

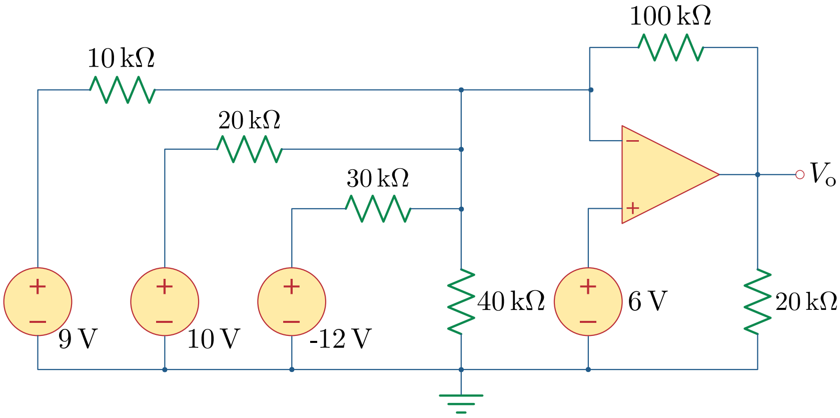
Place: Drebbelweg Exam Hall 2
Date: 07-11-2025
Time: 9:00 – 11:00

- 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 point.
- **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:
  i. a simple calculator – programmable and graphic calculators are explicitly prohibited;
  ii. 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!

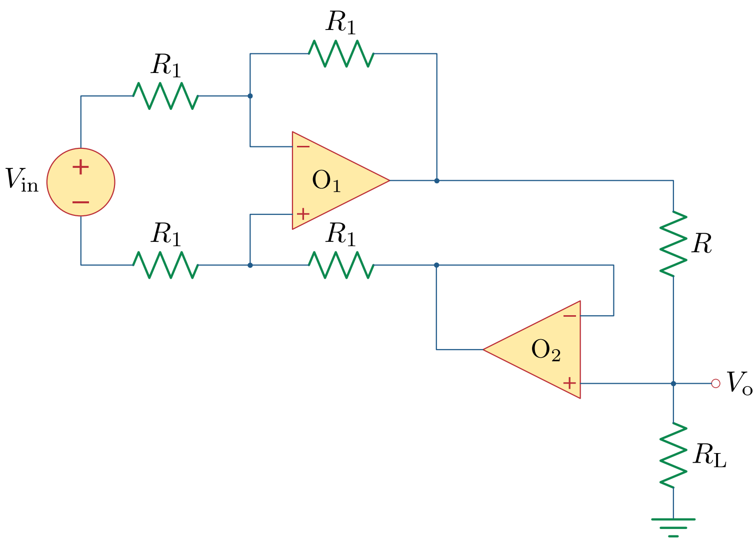
Exercise 1

Consider the circuit in the figure below, in which the op amp is taken to be ideal:



a) Calculate the output voltage V_o for the indicated input voltages. (5 points)

Now consider the circuit in the figure below, in which the op amps O_1 and O_2 are both taken to be ideal:



b) Calculate the output voltage V_o as a function of the input voltage V_{in}. (5 points)

Hints: (i) Recall that the terminal input current is always zero for ideal op amps. (ii) Examine the subcircuit comprising op amp O_2 and recognise it as a voltage follower (iii) Avoid applying KCL at the output terminal of an op amp.

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

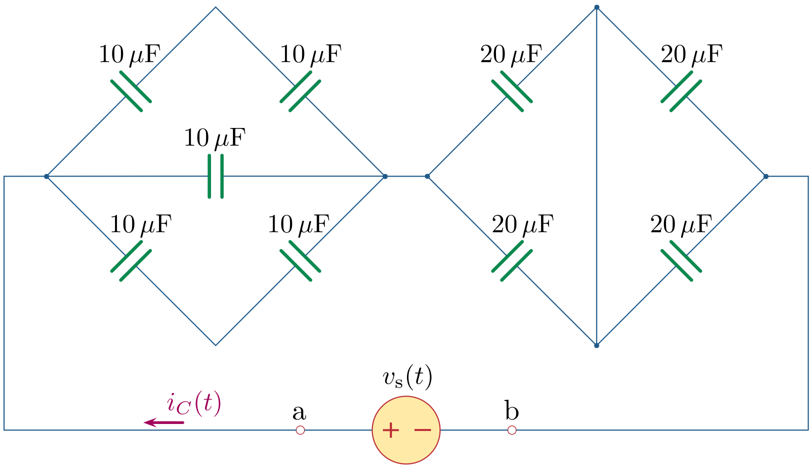
Exercise 2

The voltage at the terminals of a 100 mH inductor has the expression:

$$v_L(t) = 0.1e^{-t} + 0.2t \text{ (V)}$$

a) By knowing that $i_L(0) = 0$ A, determine the expression of the current $i_L(t)$ at $t = 2$ s. (2 points)

Consider the circuit in the figure below:



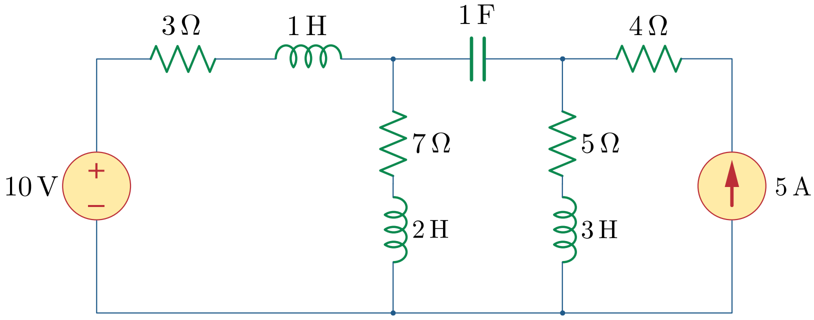
b) Calculate the equivalent capacitance C_{eq} at the terminals a–b. (2 points)

c) By knowing that the voltage source has the expression

$$v_s(t) = 3t^3 + 2t^2 + 3 \text{ (V)}$$

calculate the current $i_C(t)$ through the capacitor network at $t = 2$ s. (2 points)

Now consider the new circuit in the figure below, **operating under DC steady state conditions**:



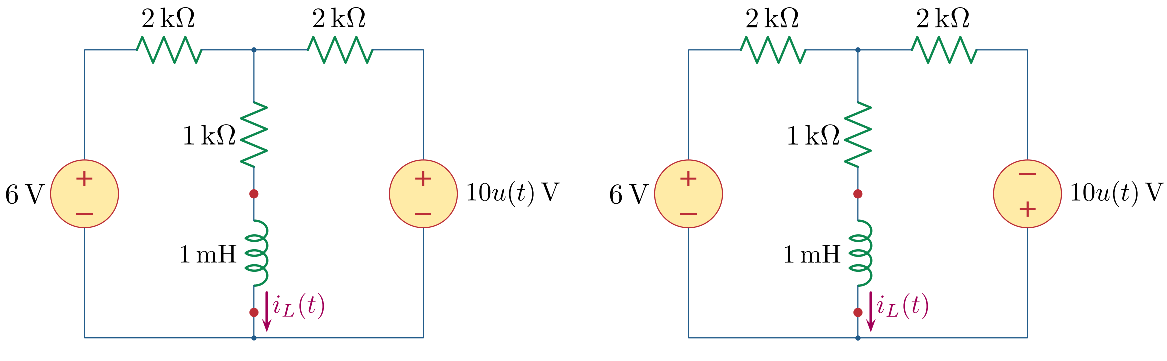
d) Calculate the total energy w_{tot} stored in the capacitor and the three inductors. (4 points)

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 subfigure (a) of the figure below:



a b

a) Calculate the value of the current $i_L(0^+)$. (2 points)

b) Calculate the value of the current $i_L(\infty)$. (2 points)

c) Calculate the circuit's time constant τ. (2 points)

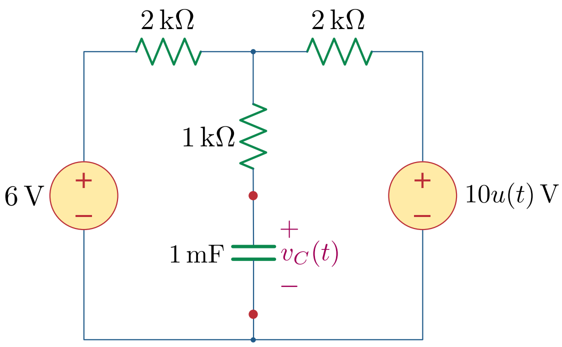
d) Determine the expression of the current $i_L(t)$ for $t > 0$. (1 point)

Assume now that the polarity of the $10\,u(t)$ voltage source is reversed, as in subfigure (b).

e) Select which ***one*** of the following statements applies: (i) only the time constant τ will change; (ii) only the value of the current $i_L(\infty)$ will change; (iii) both parameters will change; (iv) none of the two parameters will change. (1 point)

Hint: Please ***write down*** the statement that you deem correct, and justify briefly your choice (no points will be granted if no justification is provided).

Consider now the circuit in the figure below, in which the inductance was replaced in the original circuit via a capacitance.



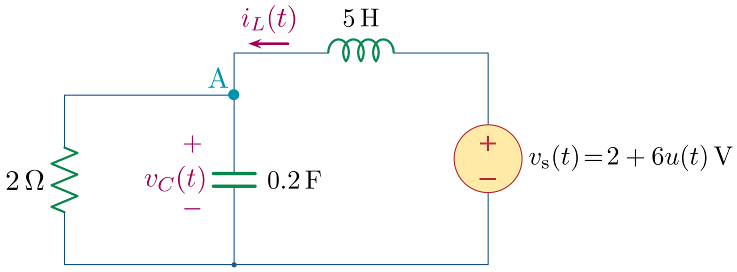
f) Calculate the new time constant τ_C. (2 points)

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 $v_C(0^+)$ and $i_L(0^+)$. (1 point)

b) Calculate $v_C(\infty)$ and $i_L(\infty)$. (1 point)

c) Apply the KCL at node A to derive an expression for the integro-differential equation for $v_C(t)$ for $t > 0$. (2 points)

d) Derive the characteristic equation and motivate if the circuit is overdamped, critically damped, or underdamped (no points will be granted if no justification is provided). (2 points)

e) Determine $v_C(t)$ 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.