

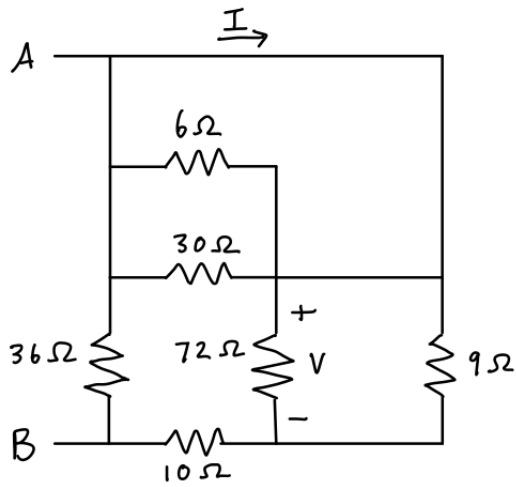
## Analog Signal Processing

Thursday, September 24, 8pm

### Exam I

- **Exam duration:** The exam is designed for **75 minutes** and you will have an additional 35 minutes to upload your solutions. The proctor will not stop the exam when the 75 minutes are up, so you could potentially keep working on the exam. However, keep in mind that there will be a **hard stop at 110 minutes** and you will not be allowed to upload after that, so we strongly advise you to finish your exam with plenty of time to spare. If your submission/upload is not completed within the 110 minutes, you will get a **zero** in the exam.
- **No collaboration allowed:** You are **not allowed** to share or collaborate on this exam and all work should be your own.
- **Open textbook:** you can use a hard copy of the textbook. However, you **should not** depend on it, browsing and searching through it will only waste your time. If you know what you are doing, you should not need any aides. Handwritten notes are **not allowed** in paper nor in your tablet nor electronic device.
- **Calculations:** Calculators and other electronic ways to do calculations, like Wolfram alpha, are **not allowed**. **Neither** is searching online.
- You will be **penalized** for unauthorized actions.
- **PDF of exam:** To solve the exam you may write on the pdf on your tablet, print the pdf and write on it, or write your solutions in blank sheets of paper. If you have paper solutions you will need to scan them at the end of the exam.
- **Solution uploads:** Make sure that your scans or photos are legible and that you correctly assign each solution to its question, or you will be **deducted** at least 5% of the corresponding problem part. Instructions for downloading the exam and uploading your solutions to Gradescope have been available on the course website since the beginning of the semester and you were instructed to try it before the exam to make sure you know how to do it.
- **Show all your work and simplify** your answers. Answers with no explanation/justification/work will be given **little/no credit**.
- **Box your answers.**
- Answers **should** include units if appropriate.

1. (25 pts) Solve the following for the circuit below with  $V_{AB} = 12V$ . Assume that the terminals A-B are not open.



- (a) [8 pts] The equivalent resistance,  $R_{eq}$ , between A and B

$$R_{eq} = \underline{\hspace{2cm}}$$

- (b) [8 pts] The voltage,  $V$ , across the  $72\Omega$  resistor.

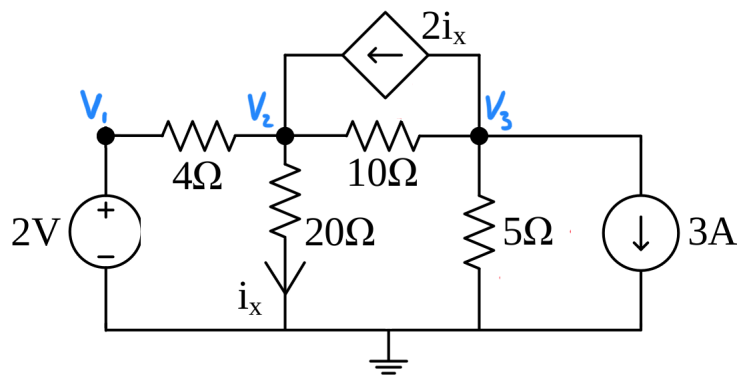
$$V = \underline{\hspace{2cm}}$$

- (c) [9 pts] The current,  $I$ , at the top.

$$I = \underline{\hspace{2cm}}$$

2. (25 pts) The two parts of this question are unrelated.

- (a) [18 pts] Consider the circuit below. Use the node-voltage method to obtain a set of three equations, in terms of the node voltages  $V_1$ ,  $V_2$  and  $V_3$ , that can be used to determine the node voltages. Then, determine the values of the node voltages. Note: equations not derived using the node-voltage method will receive no credit.



Equations: \_\_\_\_\_  $V_1$  + \_\_\_\_\_  $V_2$  + \_\_\_\_\_  $V_3$  = \_\_\_\_\_

\_\_\_\_\_  $V_1$  + \_\_\_\_\_  $V_2$  + \_\_\_\_\_  $V_3$  = \_\_\_\_\_

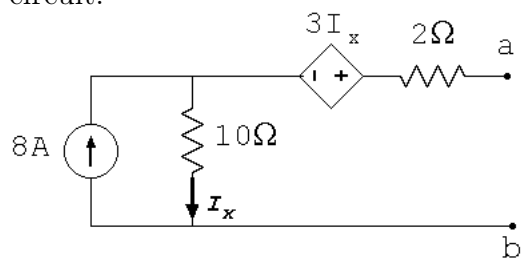
\_\_\_\_\_  $V_1$  + \_\_\_\_\_  $V_2$  + \_\_\_\_\_  $V_3$  = \_\_\_\_\_

Values:  $V_1$  = \_\_\_\_\_

$V_2$  = \_\_\_\_\_

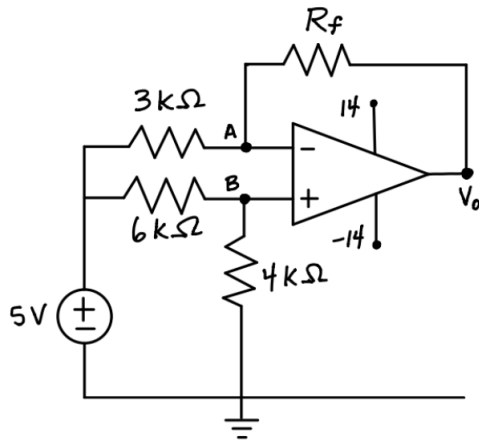
$V_3$  = \_\_\_\_\_

- (b) [07 pts] Determine Thevenin's resistance,  $R_T$ , between terminals a-b in the following circuit.



$$R_T = \underline{\hspace{2cm}}$$

3. (25 pts) Consider the following op-amp circuit, in which the op amp is powered by a DC voltage biasing source of 14 V that shares a common ground with the source (note that the bias network is not shown in the figure). You can assume that the op-amp is not saturated and it operates in ideal op-amp conditions.



- (a) [4 pts] Assuming  $R_f = 12k\Omega$ , find  $V_B$ .

$$V_B = \underline{\hspace{2cm}}$$

- (b) [5 pts] Assuming again that  $R_f = 12k\Omega$ , find  $V_0$ .

$$V_0 = \underline{\hspace{2cm}}$$

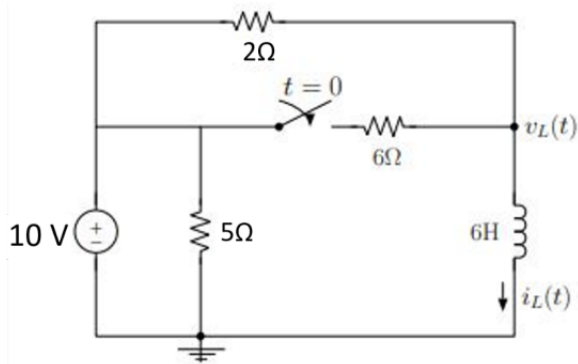
- (c) [8 pts] Assuming again that  $R_f = 12k\Omega$ , determine the absorbed power at the 5V source and indicate if it is injecting or dissipating power? Justify your answer by drawing the direction of positive current through all four resistors.

$$P_{5V} = \underline{\hspace{2cm}}$$

- (d) [8 pts] What is the maximum possible value for  $R_f$  that would keep the op-amp operating in the linear (non-saturating) regime?

$$R_f = \underline{\hspace{2cm}}$$

4. (25 pts) Consider the circuit shown below. Assume the switch has been open for a long time and it closes at  $t=0$ .



- (a) [5 pts] Find  $v_L(0^-)$  and  $i_L(0^-)$ .

$$v_L(0^-) = \underline{\hspace{2cm}}$$

$$i_L(0^-) = \underline{\hspace{2cm}}$$

- (b) [10 pts] Determine  $i_L(t)$  for  $t > 0$  and **sketch** it for  $t > -1$ .

$$i_L(t) = \underline{\hspace{2cm}}$$

**sketch**

- (c) [10 pts] Find  $v_L(t)$  for  $t > 0$  and **sketch** it for  $t > -1$ .

$$v_L(t) = \underline{\hspace{2cm}}$$

**sketch**