ME 103 Discussion 1

Week of 1/19

Syllabus Review - Contact Information

Course staff

Name	E-mail	Office hours
Dr. George Anwar Course instructor	ganwar@berkeley.edu	Monday, Wednesday, Friday 10:00 AM – 12:00 PM, Hesse 50B
Steph Akakabota (they/ them) GSI	sakakabota@berkeley.edu	Tuesdays 1:00 - 2:00 PM, Hesse 50B + Thursdays 1-2PM
Larry Hui GSI	larryhui7@berkeley.edu	Wednesday 12:00 - 2:00 PM, Hesse 50B, or by request!
Dalil Ashong Tutor	dalilashong@berkeley.edu	Friday 9:00 - 10:00 AM, Hesse Fishbowl (subject to change)
Alyn Panggabean Tutor	alyn@berkeley.edu	N/A

Class Website :)

- This semester, we are also going to have a course website in an effort to help keep the course more organized.
- All lecture recordings, lecture pdfs, discussion recordings, notes, textbook, homework, OH schedule, syllabus, important lab and project details will be found there!
- Please email any TA if you have questions or suggestions. Link: ucb-me103.github.io/me103-sp26site
    - bookmark it!

Syllabus Review - Lab Structure

- Labs will begin next week in Hesse 122, please bring your Microkit!
- Groups of 3-4 students (some exceptions can be made)
- At least 1 Microkit per group
- Labs will be due by the minute before your next lab.
    - i.e. Tuesday 2-5pm's lab is due the following week at 1:59 pm.
- If you have any questions during lab, we will also be trying bearqueue[1].

[1] Thanks Elliot! Hopefully, it will be ready by next week!

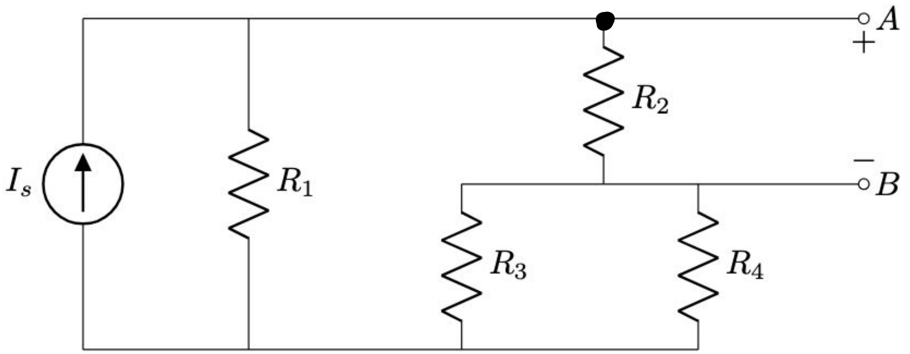
Note about LaTeX

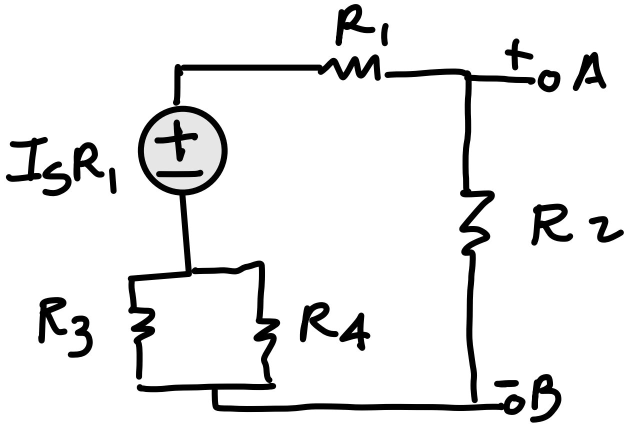
- All assignments you are handing in for ME103 should be typeset in LaTeX. We recommend that you
  - use Overleaf, an online LaTeX editor!
  - edit locally using TeX Editor or VSCode
- You **DO NOT** need to draw diagrams using Tikz (this would be unnecessarily cruel...) However, if you are going into academia, it might be helpful to learn how. https://tikzmaker.com/editor is a great tool to get started!
- Ask Larry for any LaTeX help.

Thévenin/Norton Equivalent Circuits

$V_{th} I_s = R_{th}$

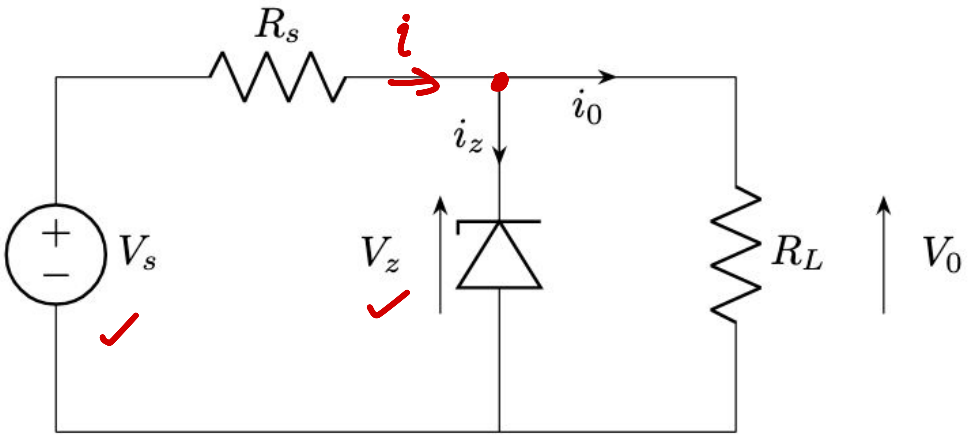
- Replace current and R_1 with voltage source $I_s R1$ in series with R_1.
- V_{th} is V at node a, or Voltage through R_2, voltage divider eq
- Short voltage source and find equivalent resistance to find R_{th}.





Zener Diodes as Voltage Regulators

- Uses:
  - To vary or regulate the output voltage
  - Rs varies to regulate the current through the diode.
  - **Turns off if V_Z gets below its specific (breakdown) voltage (i.e. current too high, resistance too low)**
- Zener C9V4 = $\boxed{9.4\text{ V}}$ = V_Z
- Junction Math = $i_z = (V_s - V_z)/R_s - i_0$
- When load is disconnected, $i_0 = 0$
- P = IV → get i_z → solve for R_s



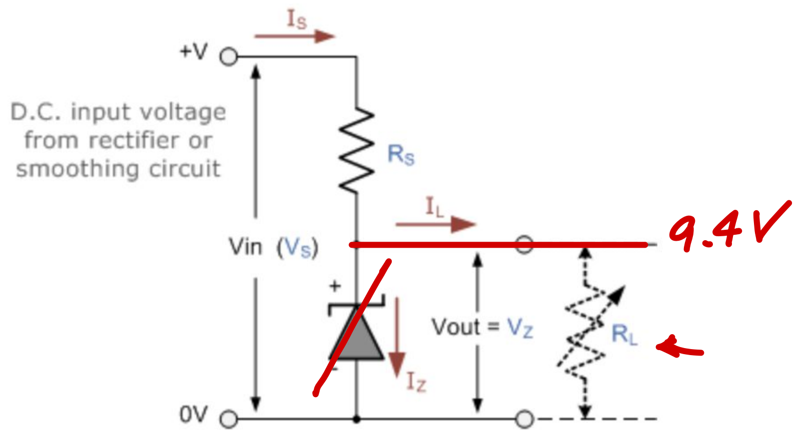
Zener Diodes as Voltage Regulators

$P = IV$

$\frac{7.5W}{9.4} = 0.8A$

10Ω 50Ω 100Ω

- Current over the load (i_0) cannot exceed maximum current for diode = $i_{z,max}$ = 7.5/9.4 = 0.8 A. Check if the resistances are high enough to ensure that the diode stays ON.
- If the diode is OFF, no current goes through that path →Simple voltage divider
  - $P = V_0^2/R_L$
- Diode is on for current below 0.8 A → Voltage stays at 9.4V



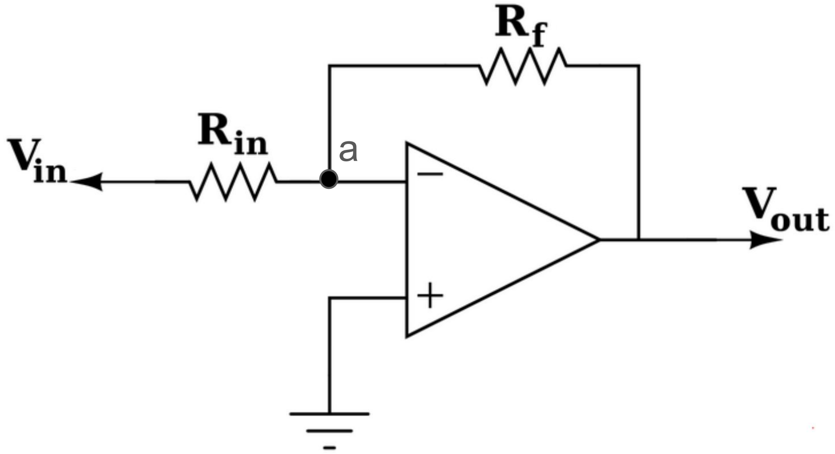
$P = \frac{9.4V^2}{50\Omega}$

$\frac{9.4}{10} = 0.94A$

$P = \frac{9.4V^2}{100\Omega}$

Inverted Op Amp

- Golden Rules:
  - V- = V+
  - i- = i+ = 0
- Perform nodal analysis at a
- DC Gain = $-R_f/R_{in}$



Active Op Amp (inverting)

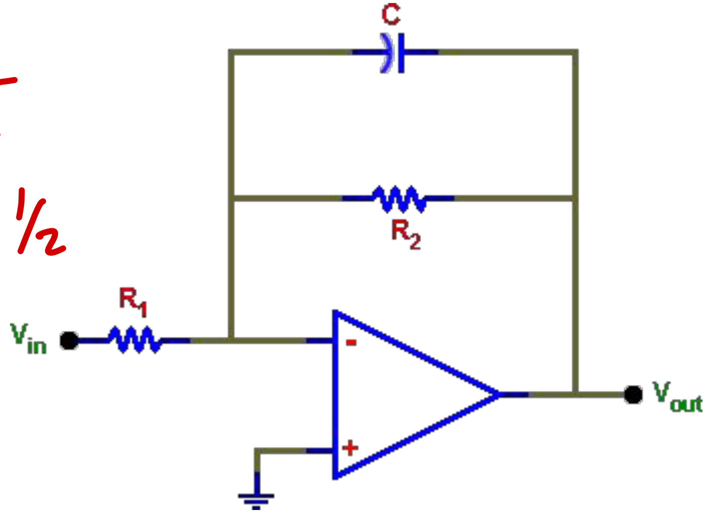
$$\frac{V_o^2}{\cancel{R_1}} = \frac{V_{in}^2}{2\cancel{R}} \qquad \frac{V_o^2}{V_{in}^2} = \frac{1}{2}$$

- $P = V^2/R$
- $P_{output} = P_{input}/2$
- $V_{out}^2/R1 = V_{in}^2/R2$
- $R1 = R2$
- Transfer function |H| is the ratio between V_out and V_in.
  - Use algebra to solve for H
  - Use H to solve for ωRC and plug in to solve Φ

$$|H| = \frac{R_2}{R_1}\frac{1}{\sqrt{1+(\omega R_2 C)^2}}, \qquad \phi = 180^\circ - \arctan(\omega R_2 C)$$

$$|H| = \frac{V_o}{V_i}$$

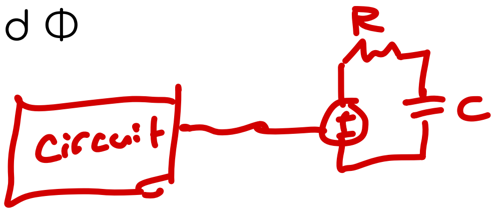
$$|H|^2 = 1/2$$

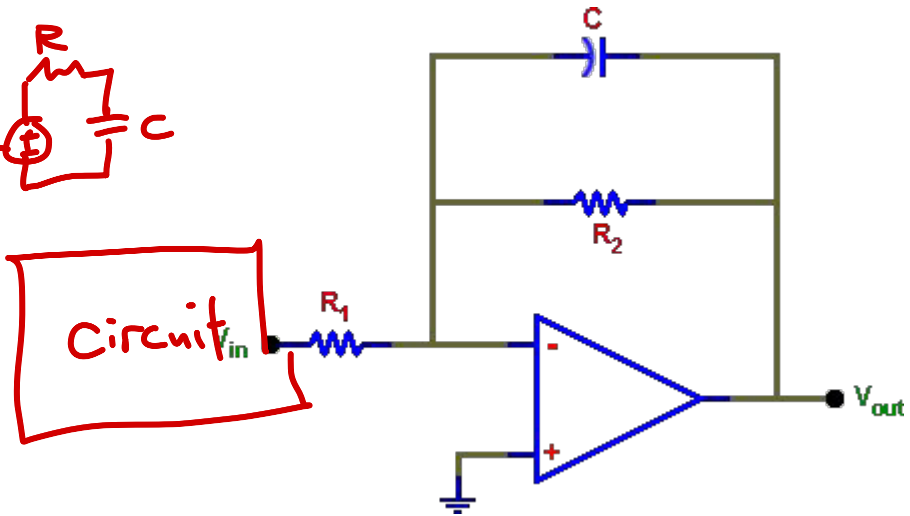


Active Op Amp (inverting)

- DC input means no frequency.
- $\omega = 0$
- Solve for |H| and Φ

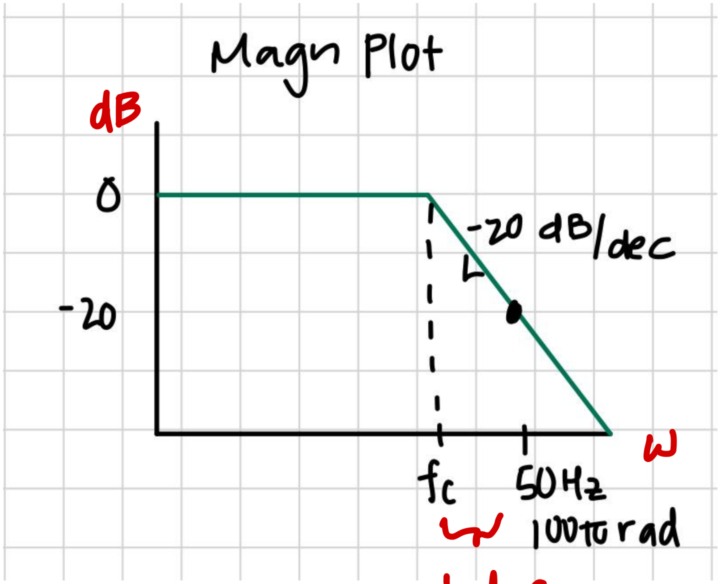
$$|H| = \frac{R_2}{R_1}\frac{1}{\sqrt{1+\cancel{(\omega R_2 C)^2}}}, \qquad \phi = 180^\circ - \arctan(\omega R_2 C)$$





Active Op Amp (inverting)

- Magnitude Plot for a Low Pass Filter
  - 20 Db are attenuated at 50 Hz.
  - Cut off frequency is at 0 dB.
  - Slope after cutoff is always -20DB per decade (10^1) increase in frequency.
  - 10^1 must have passed since cutoff frequency
- Solve for C
- R is V/I (given in problem)



1 dec

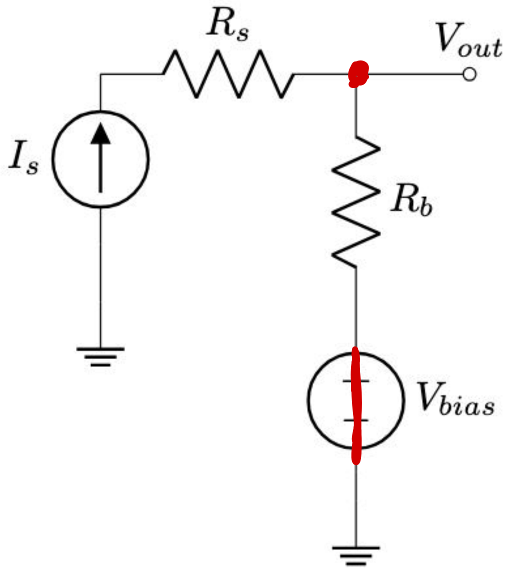
10^1

$$f_C = \frac{1}{2RC\pi} = \frac{50}{10} = 5\text{Hz}$$

Superposition

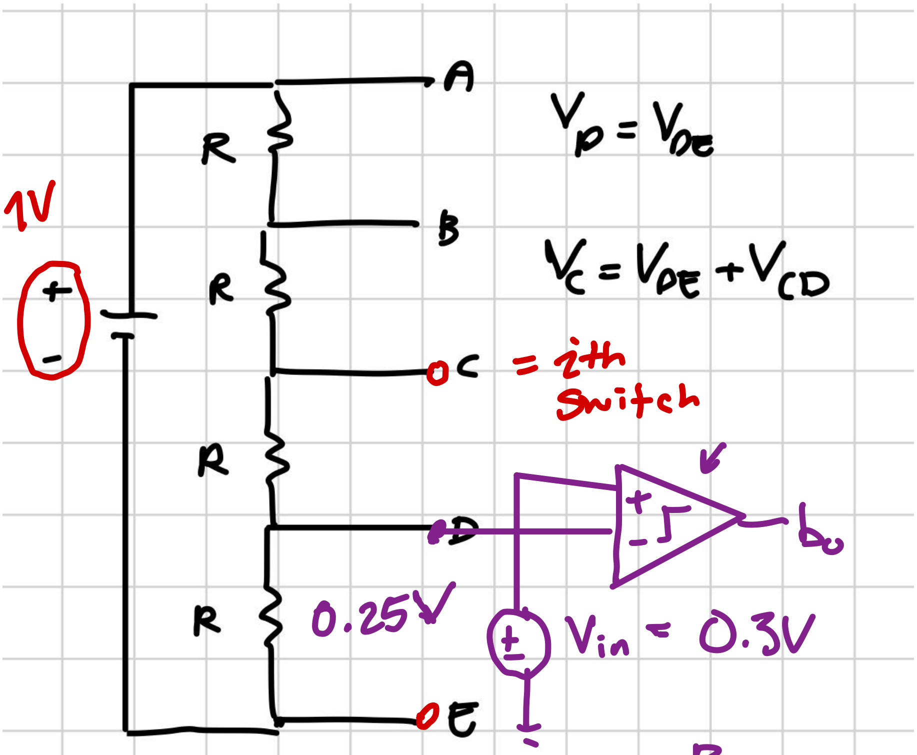
- Turn off current source, find Vout,1.
- Turn off voltage source, find Vout,2.
- Vout = Vout,1 + Vout,2

V_{bias} $\quad$ $I_s R_b$



Resistor Ladder

- Resistors split voltage into N equal parts (in this case, N=4).
- If switch C is closed, voltage drop across CE gives Vout
- Voltage drop CE = Voltage drop across DE + CD
- Comparator outputs V_{DD} if voltage drop is less than 0.3V and V_{SS} if not.



$$V_{out} = \frac{R_{bottom}}{R_{total}} V_{in} \qquad \frac{iR}{NR} V_{in} \qquad V_{out} = \frac{R}{4R} 1 = 0.25V$$

Capacitor

- Use basic Q and I equations to get voltage derivative.
- Integrate both sides to get voltage in terms of current and initial voltage (init voltage is 0)
- Plug in values for I, V and t and solve for C (remember constants get taken out of integrals)

$$\boxed{I = \frac{dQ}{dt}} \qquad \boxed{Q = CV}$$

$$\frac{dQ}{dt} = C\frac{dV}{dt}$$

$$\Rightarrow \int_0^t \frac{dV}{dt} = \int_0^t \frac{1}{C} I(t)$$

$$v = \frac{1}{C}\int_0^T i\,dt + v_0$$

$i(t) = 5nA$

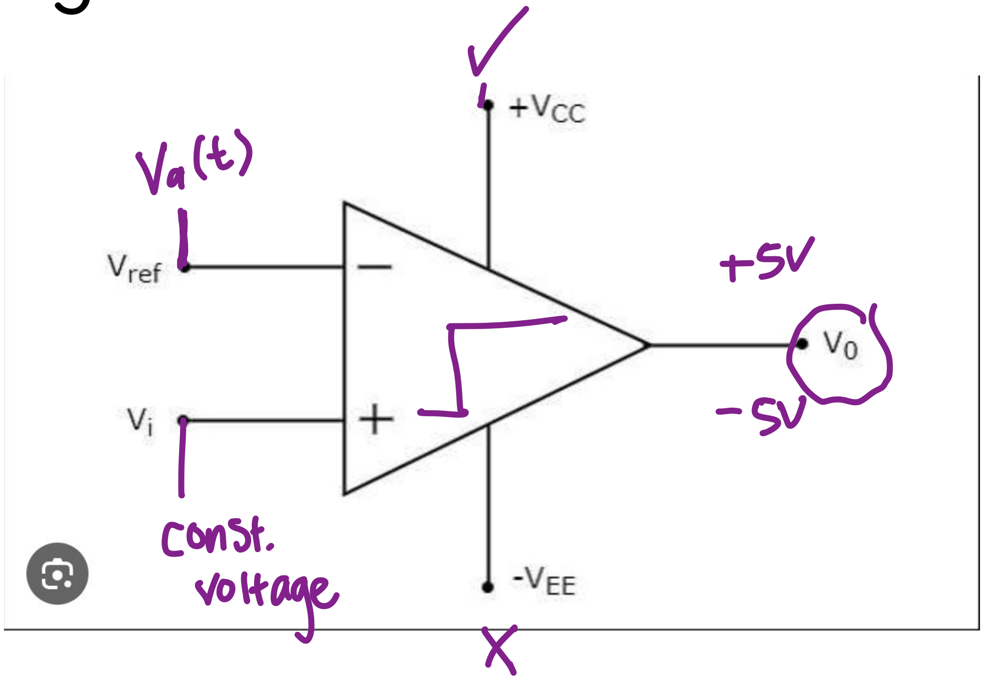
$t = 1hr$

$V_{out} = 5V$

$V_0 = 0$

Comparator Circuit Design

- V_{CC} (output when reference is higher than input)
- $-V_{EE}$ (output when reference is lower than output)
- V_i (input voltage you are comparing to reference, constant)
- What you have
  - Comparator
  - $V_a(t)$ - gives +5V after an hour of exposure
- What should you compare Va to to ensure that the output switches from V_{EE} to V_{CC} when an hour of sunlight is reached?

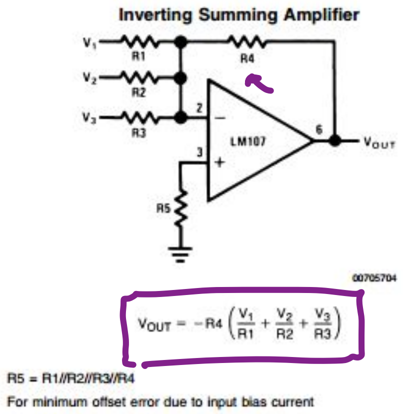


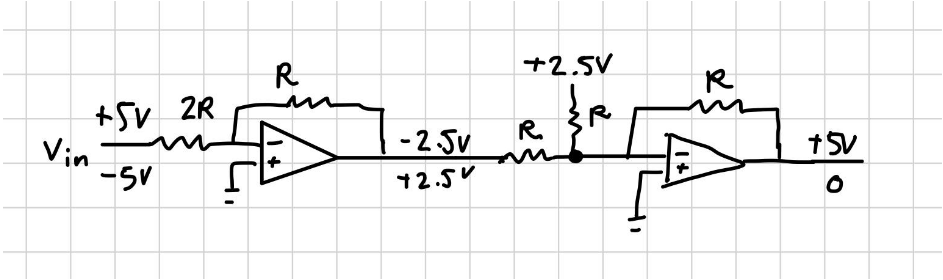
Shift + Scale Op Amp Circuit

- Goal: go from (-5V → +5V) to (0V → 5V)
- This means halving Vin 1 (-2.5V → 2.5V), then adding 2.5 (0V →5V) 2
- Half V in with a gain of ½. Then use a summing amplifier to add 2.5 V

$$V_o = 1 + \frac{R_2}{R_1} V_i$$

$$V_o = -\frac{R_2}{R_1} V_i$$





- Stage 1 Gain = R/2R = ½. Multiples V in by -½
- Stage 2 Adds 2.5 V with a summing junction and multiplies by -1 flipping voltage to 0V → +5V.