Lecture 23 – Q/A session for MT II.

Administrivia → Grade corrections will be addressed after MT II

→ Justin's review session tonight (5 - 7) in 101 Morgan

→ Review problem solutions up by tonight

Note: TBP Telebears advising sessions

- → Tu Apr. 12
- → Mon. Apr. 18
- → Wed. Apr. 20th

6 pm - 8 pm, Wozniak Lounge, 4th floor Soda hall

(FREE FOOD!)

Midterm II

→ (1) op-amps I (cascade?) (25 points)

(2) Dynamic route I (eg: oscillator) (30 pts)

(3) Dynamic route II (eg: flip-flop) (30 pts) [lecture 20]

(4) op-amp II (difficult?!) (12 pts)

Total: 100 pts

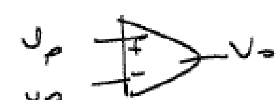
[3 points for filling out front page correctly]

Important concepts:

Eq. point: $f'(t) = 0$

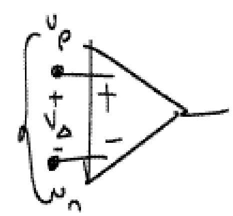
Dynamic route: Illustrate $(i(t), v(t))$ on i-v graph

op-amps → linear: $v_o = A(v_p - v_n)$



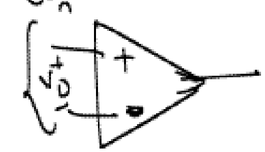
op-amps → saturation (i.e. railing)

$v_\Delta > 0$



v_o = +ve rail

$v_\Delta < 0$



v_o = −ve rail

$v_{in} = 1\,V$, $V_o = \left(1 + \frac{1k}{1k}\right) 1\,V$

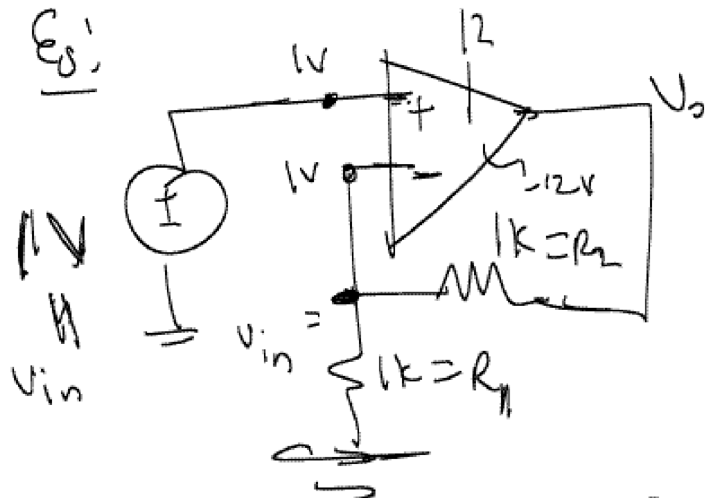
$= 2.1 = 2\,V$

since $2\,V < 12\,V$

⇒ op-amp does not rail

⇒ $v_p \approx v_n = 1\,V$

Eg:

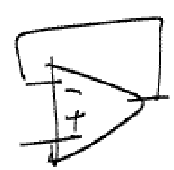


Non-inverting topology: $V_o = \left(1 + \frac{R_2}{R_1}\right) V_{in}$

Cheat sheet: inverting amplifier

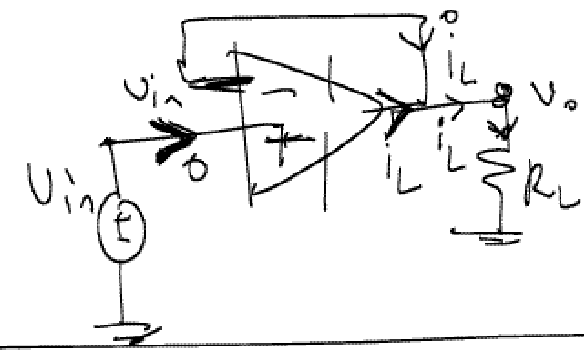
noninverting amplifier

voltage follower →



inverting summing amplifiers, differential amplifier

Note: Purpose of voltage follower:

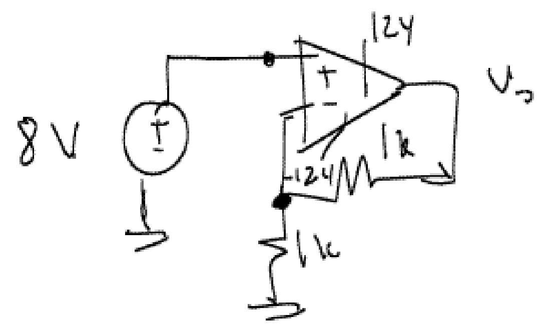


$V_o = V_{in}$, $i_L = \frac{V_o}{R_L} = \frac{V_{in}}{R_L}$

[ignore rails]

⇒ V_{in} does not put out any current, op-amp does all the work!!!

Eg 2:

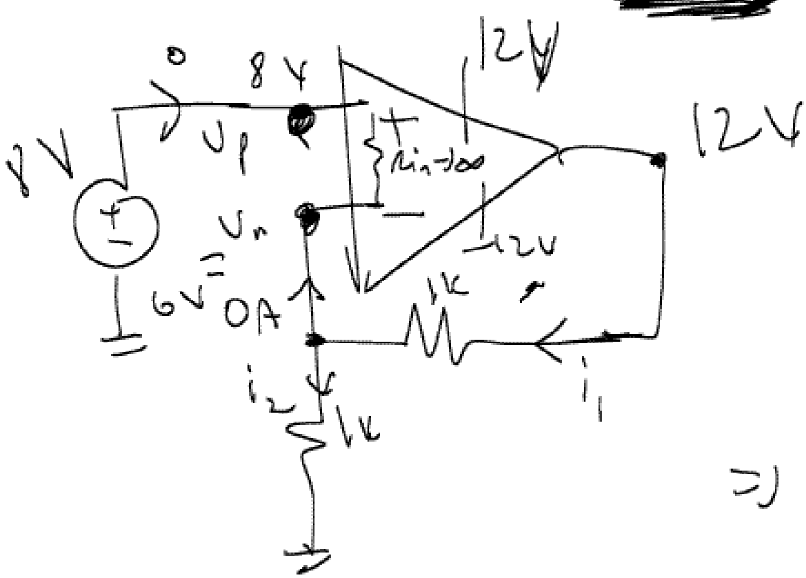


$V_o = \left(1 + \frac{1k}{1k}\right) 8V$

$= 2 \cdot 8 = 16\,V$

Oops, $v_o = 12V$ (op-amp rails)

i.e., $V_o = \left(1 + \frac{R_2}{R_1}\right) v_{in}$ is invalid

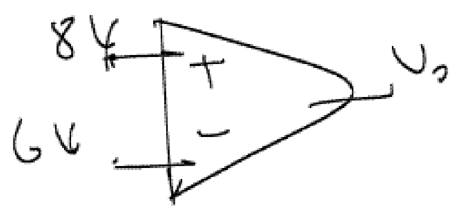


$i_1 = i_2$ (KCL @ v_n)

$\Rightarrow \frac{12 - V_n}{1k} = \frac{V_n}{1k}$

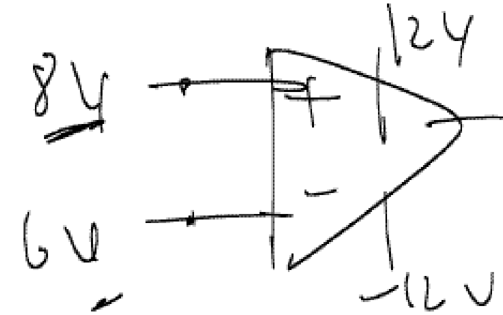
$\Rightarrow 12 = 2V_n \Rightarrow \boxed{v_n = 6\ V}$

Notice:

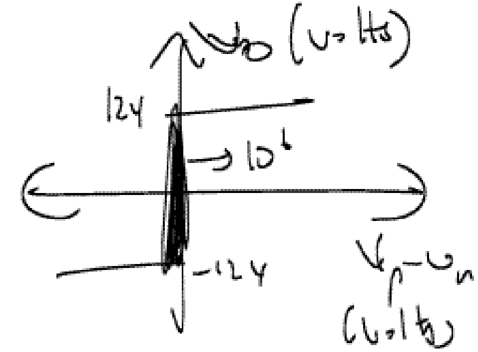


$\boxed{V_o = A\,(\overset{v_p}{8} - \overset{v_n}{6})} \approx 2 \times 10^6\ V$

$A \approx 10^6$

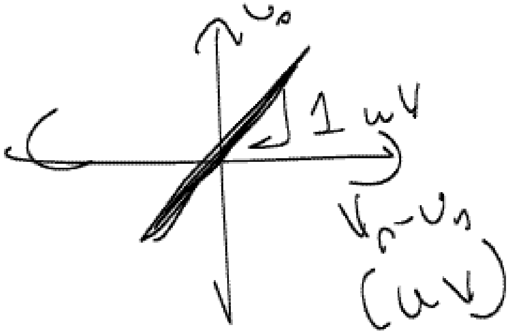


$V_o = 2 \times 10^6 \, V$



$V_o = A(V_p - V_n) \Rightarrow \frac{V_o}{V_p - V_n} = 1 \, \mu V$

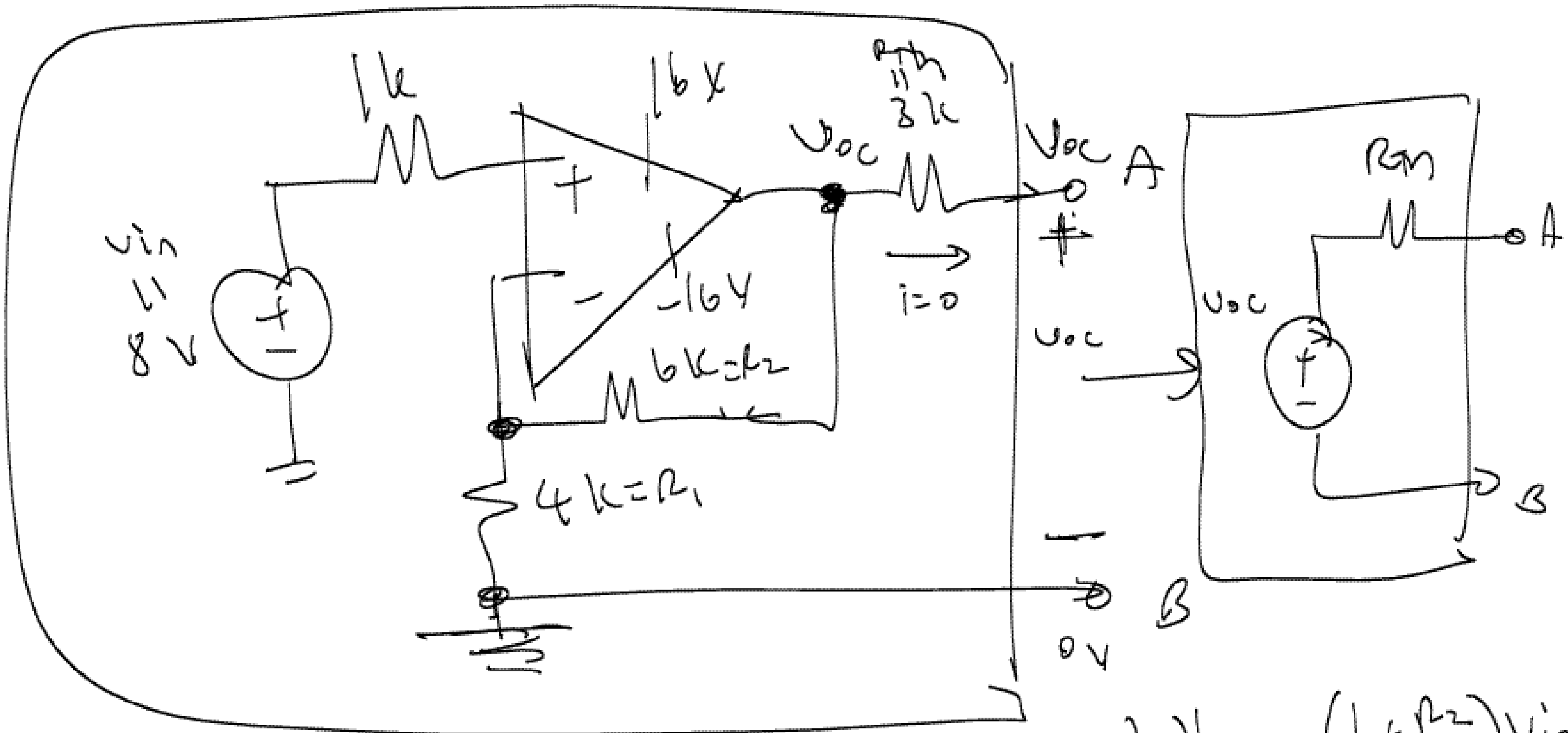
$A \to 10^6$, $(V_p - V_n) \approx 10^{-6}$



$\Rightarrow V_o$ will be in volts

Questions on Review Problems

2(b): Thev. equivalent at AB:



V_{oc} = Output voltage of the op-amp

$V_{oc} = \left(1+\frac{R_2}{R_1}\right)V_{in}$

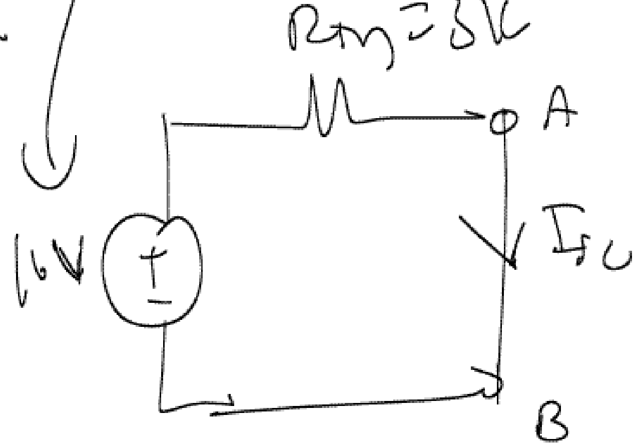
op-amp verify!

$V_{oc} = 16\text{ V}$

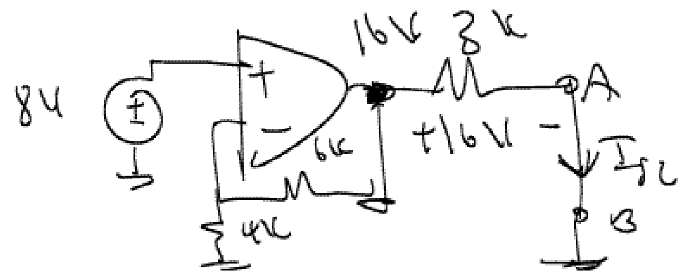
$= \left(1 + \frac{6k}{4k}\right) 8$

$= 2.5 \cdot 8\text{V} = 20\text{ V}$

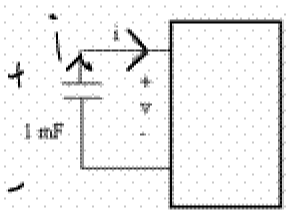
fixed by the op-amp

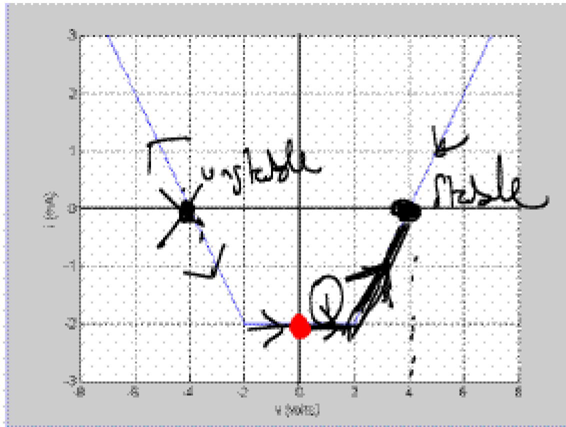


$I_{sc} = \frac{V_{oc}}{R_{th}}$



$I_{sc} = \frac{16\text{V}}{3k}$

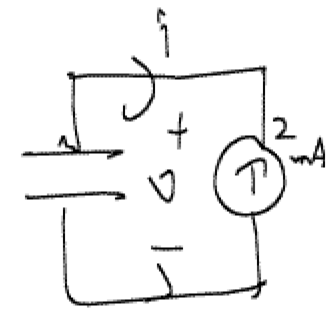


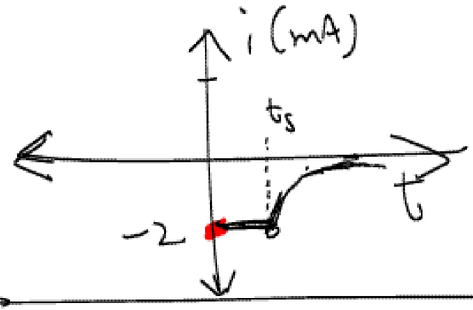


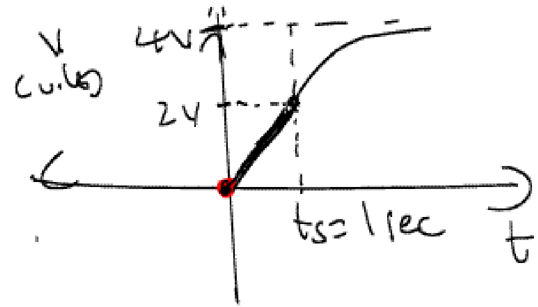
The i-v graph of the nonlinear circuit element is shown in the figure above. Assuming v(0) = 0 V:

(a) Find the equilibrium points and sketch the dynamic route.

(b) Sketch i(t) and v(t), make sure to mark the switching times on the graph(s).



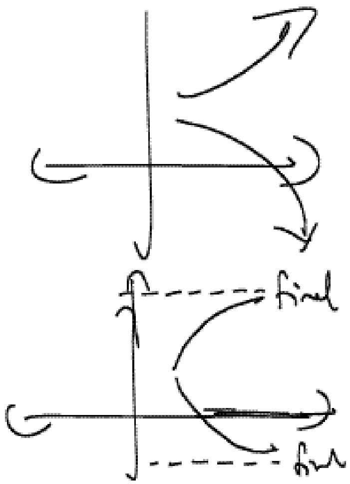




Note!

Unstable:

Stable:



$$i(t) = \begin{cases} -2 \text{ mA} & \text{if } t < t_s \\ -2e^{-\frac{(t-t_s)}{\tau}} \text{ mA} & \text{if } t \geq t_s \end{cases}$$

$i(t) = -2$ mA for $t < t_s$

$$\Rightarrow -(1\text{ mF})\frac{dv}{dt} = -2 \text{ mA}$$

$$\Rightarrow \frac{dv}{dt} = 2 \Rightarrow v(t) = 2t + v_{initial}$$

$v_{initial} = v(0) = 0$ V

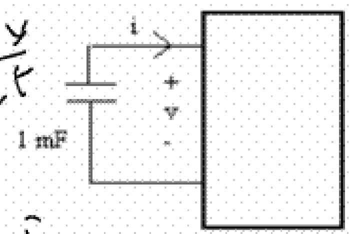
$$\therefore \boxed{v(t) = 2t \text{ volts}}$$

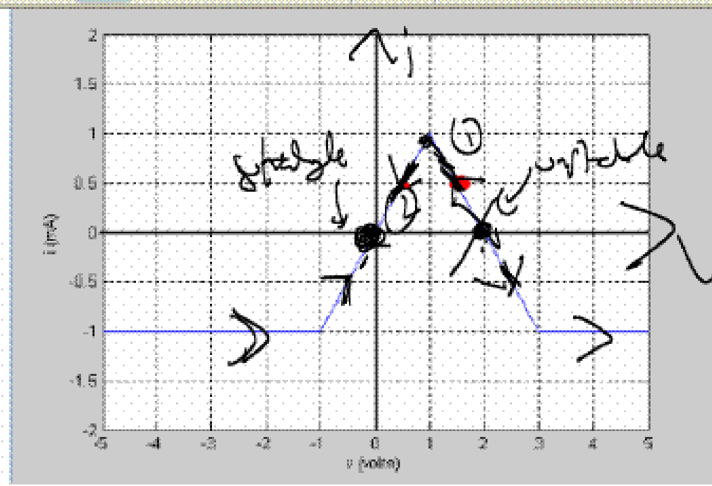
$$v(t_s) = 2V \Rightarrow \boxed{t_s = 1 \text{ second}}$$

Problem 7

(a)

$i = (-1\,mF)\frac{dv}{dt}$





$\frac{dv}{dt} = 0 \Rightarrow i = 0$

$i > 0,\ v' < 0$

$i < 0,\ v' > 0$

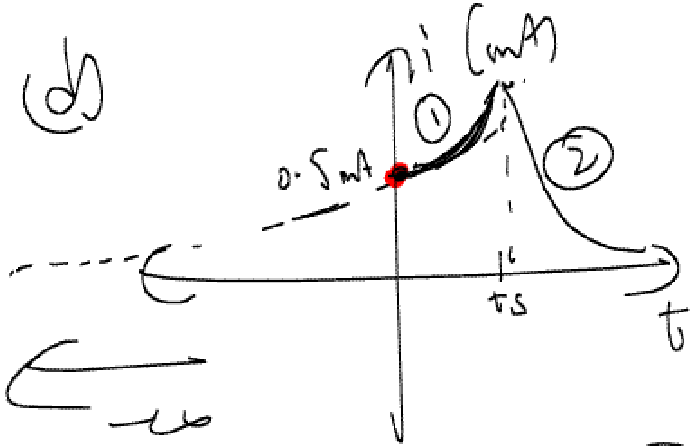
The i-v graph of the nonlinear circuit element is shown in the figure above. Assuming i(0) = 0.5 mA: , v(0) = 1.5 V

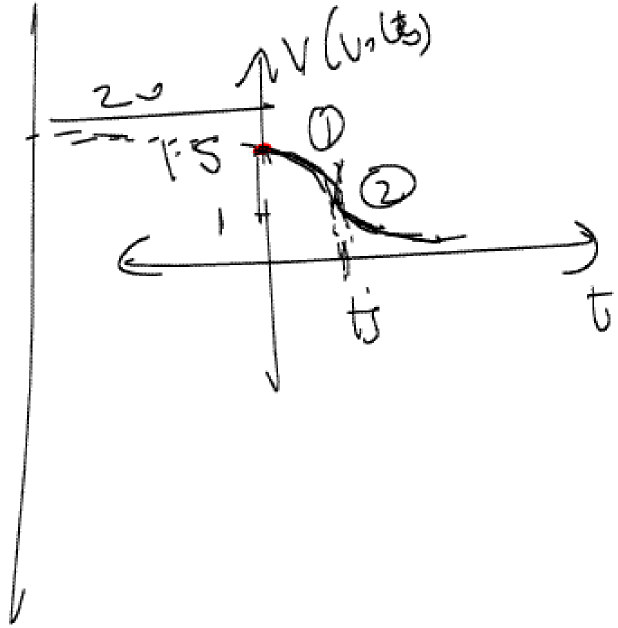
(c) Find the equilibrium points and sketch the dynamic route.

(d) Sketch i(t) and v(t), make sure to mark the switching times on the graph(s). **(Hint: for the unstable part, think carefully about the final values of i and v).**

You should look over the flip-flop example from Lecture 20 on the EE100 homepage. **MAKE SURE YOU UNDERSTAND THIS PROBLEM FOR THE MIDTERM!** Of course, you could surf http://hkn.eecs.berkeley.edu/student/onlineexams.shtml for online

(d)





$$i_{①}(t) = i_f + (i_i - i_f)e^{-t/\tau}$$

i_f ↓ 0 V; i_i ↓ 0.5 mA

$$i_{①}(t) = i_f + (i_i - i_f)e^{t/\tau}$$

$(i_i - i_f)$ ↓ > 0