HW, Lab

OH for now Tues 11-12
F 4-5

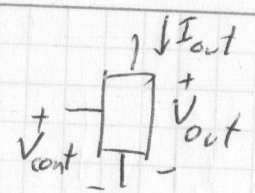
large signal

$A_v = -G_m R_o$

small signal

Device Models

lots of things look like



where V_{cont} has big impact on I_{out}

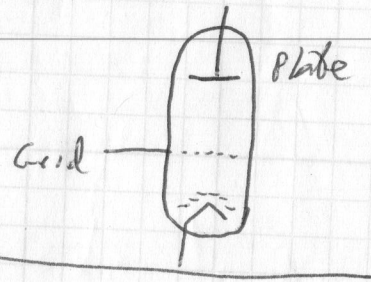
V_{out} has a small impact on I_{out}

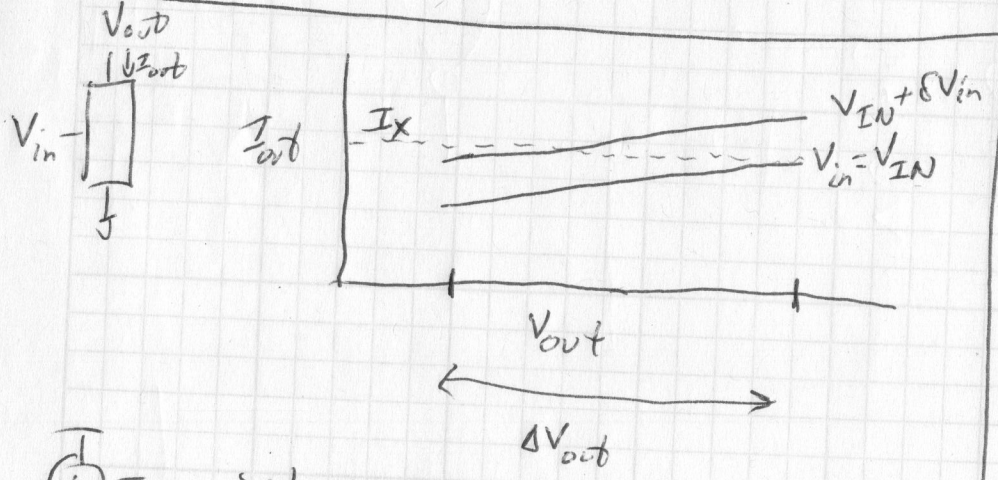
Vacuum tube - triode (rentode) 1907

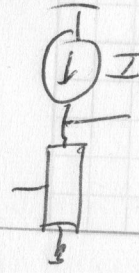
BJT 1947

NFET 1927 !

JFET



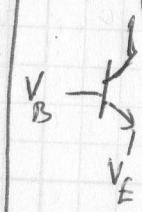




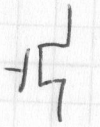
$\delta V_{in} << \Delta V_{out}$

$A_V = \frac{\Delta V_{out}}{\partial V_{in}}$

Large Signal Models



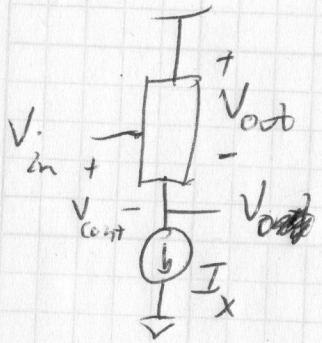
$$I_c = I_s\left(e^{V_{BE}/V_T} - 1\right)\left(1 + \frac{V_{CE}}{V_A}\right)$$

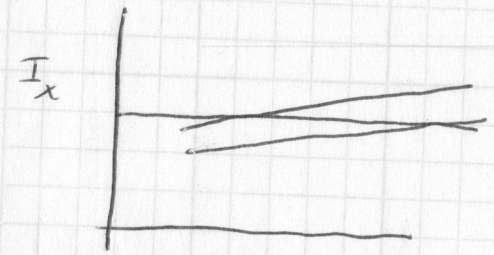


$$I_D = \begin{cases} 0 & V_{GS} < V_{th} \\ \frac{\mu_n C_{ox}}{2}\frac{W}{L}\left(V_{gs} - V_{th}\right)^2\left(1 + \lambda V_{DS}\right) & V_{GS} > V_{th} \\ \cdots \end{cases}$$

14/240A 17 SP W/L 2

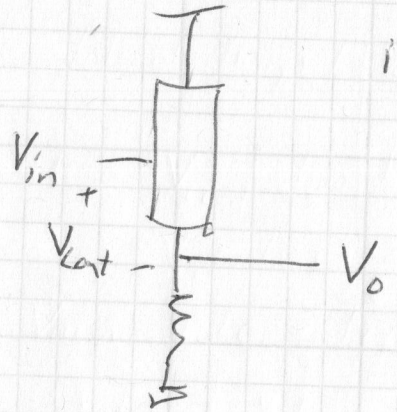
large signal behavior – follower





V_{cont} will not change much

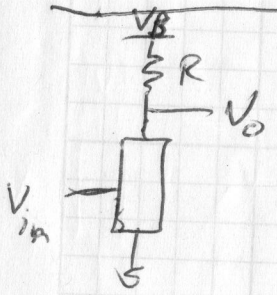
V_o must follow V_{in}

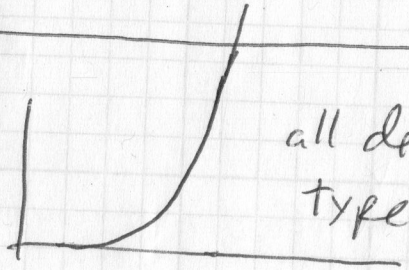


if V_o changes 10×

I_{out} changes 10×

how much does V_{cont} change?





all device types

change in region of operation

what happens ? here?

What is the gain?

How to get gain?

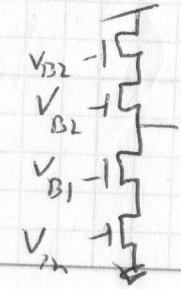
① solve non-linear equations

$$V_o = V_{CC} - I_R R_L$$

$$= V_{CC} - I_S\left(e^{V_{in}/V_T} - 1\right)\left(1 + \frac{V_o}{V_A}\right)$$

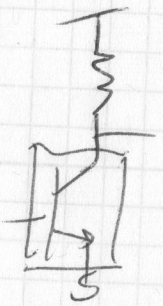
Painful w/ 1 device

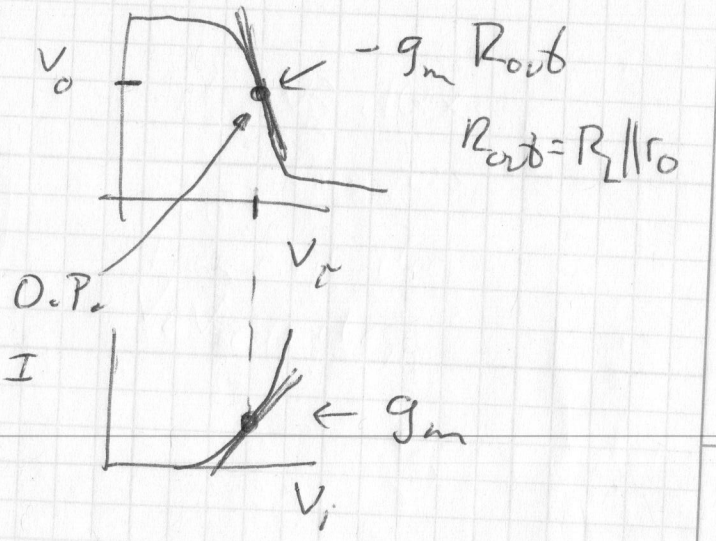
≈ impossible w/ more than 2



(2A) find a bias point
operating point
known useful set of
voltages & currents
⇒ still solving nonlinear equations
but just for one pt, not for
the whole curve

(2B) linearize at that point





$$\left(\begin{array}{c}\text{full nonlinear}\\ \text{dynamics}\end{array}\right) = \left(\begin{array}{c}\text{single}\\ \text{point}\\ \text{solution}\end{array}\right) + \left(\begin{array}{c}\text{small}\\ \text{signal}\\ \text{model}\end{array}\right) + \text{h.o.t}$$

↑ DC and freq response!

↑ nonlinear O.P.

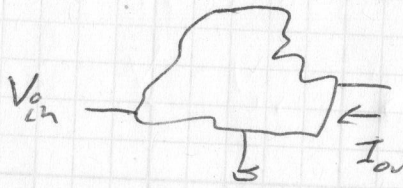
↑ linearization

↑ error

Heaviside

Taylor

where does $A_V = -G_m R_{out}$ come from?



f exists s.t. $I_{out} = f(V_{in}, V_{out})$ in some nbhd w/ cont derivatives,
find a point (V_{IN}, V_{OUT}) s.t. $I_{out}(V_{IN}, V_{out}) = 0$
that's an O.P.
near that point $I_{out}(V_{IN}+\delta_{in}, V_{out}+v_{out}) =$