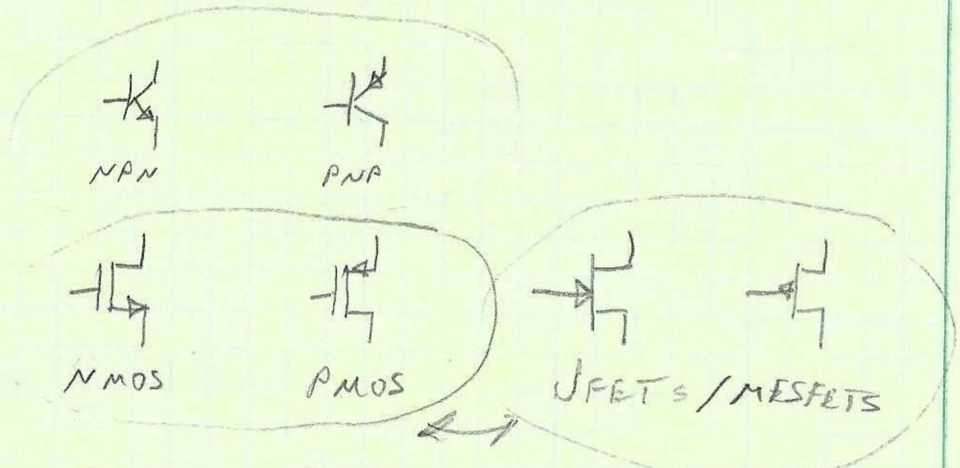
# Electronics Review

## Transistors

BJTs

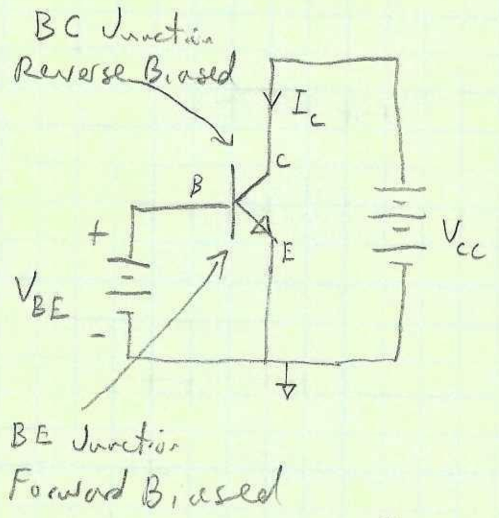
FETs

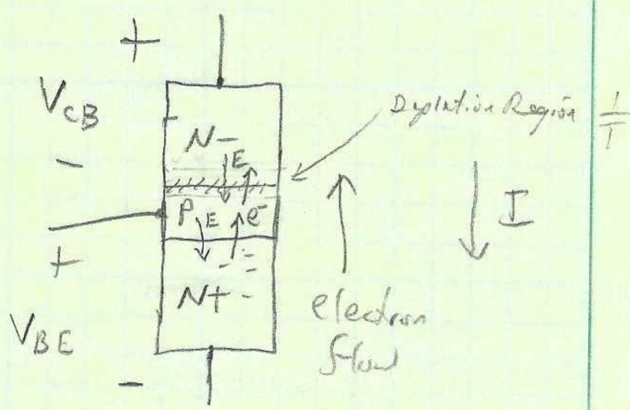



We will concentrate on BJTs
but theory developed is general

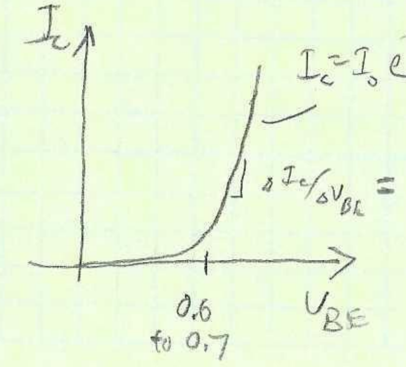
## BJTs

Recall ~~BJT~~ Structure & Operation



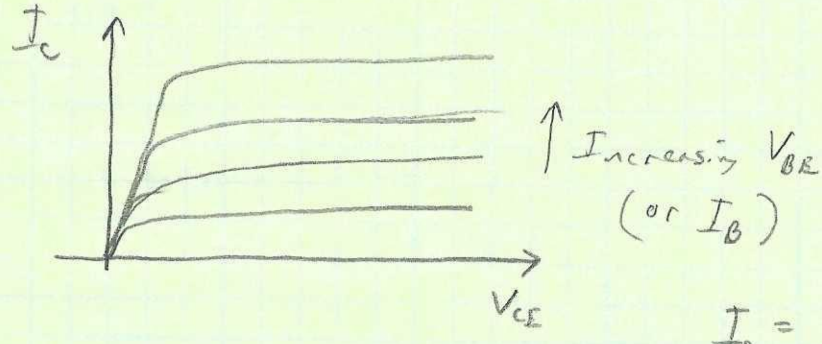

## IV Curves




$I_C = I_0 e^{\frac{V_{BE}}{nV_T}}$

$V_T = \frac{kT}{q} = 0.026$ V

$1 < n < 2$ 1.5 typically

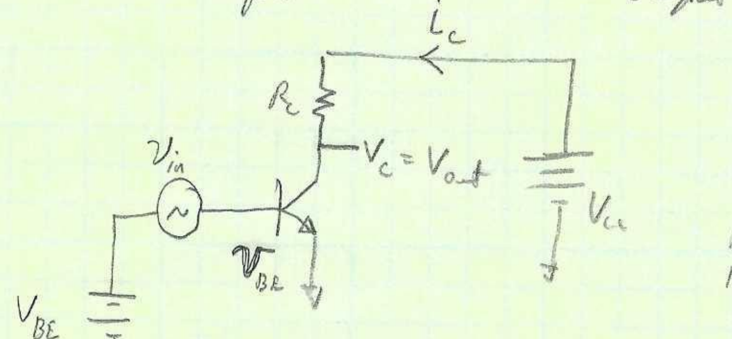


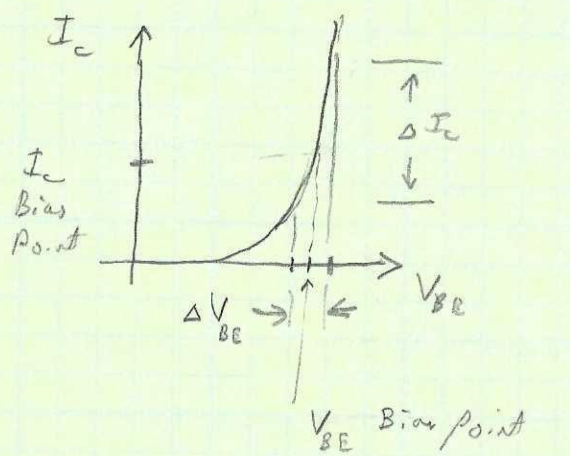

$$I_B = \frac{1}{h_{FE}} I_c \quad \text{why?}$$

($h_{FE}$: 30 to 300 (a.k.a "$\beta$"))

## Basic Amplifier Concept

- Add resistor between $V_{cc}$ and Collector
- Vary $V_{BE}$ with input signal
- $\underbrace{\Delta V_{BE}}_{\text{input}} \rightarrow \Delta I_c \rightarrow \underbrace{\Delta V_c}_{\text{output}}$ $\qquad \Delta V_c = (\Delta I_c)(R_c)$




### Amplifier Voltage Gain:

$$\Delta V_c = -\Delta I_c \, R_c \quad \text{(why?)}$$

$$= -\Delta V_{BE} \left( \frac{d I_c}{d V_{BE}} \right) R_c$$

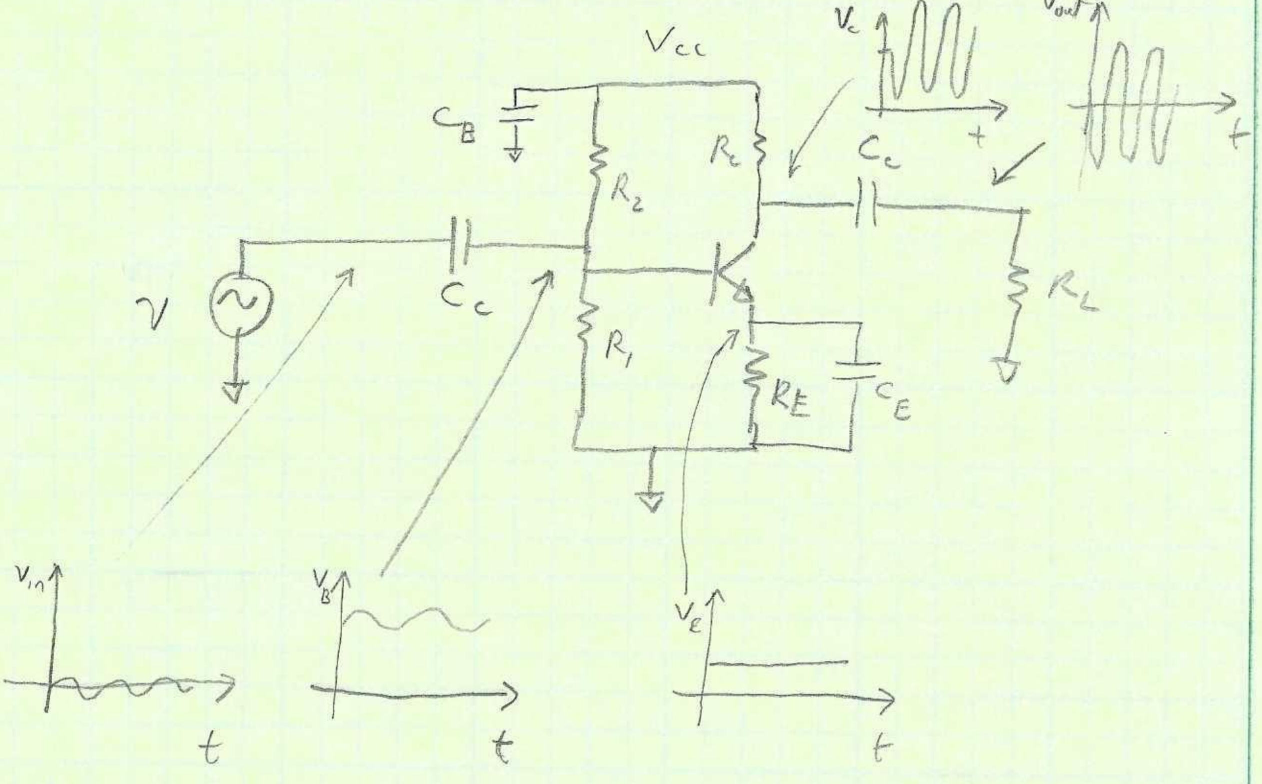
$$\boxed{\frac{\partial I_c}{\partial V_{BE}} = g_m \equiv \frac{I_c}{n V_T}}$$

$$= -\Delta V_{BE} \; g_m \; R_c$$

$$\Rightarrow A_V = \frac{\Delta V_c}{\Delta V_{BE}} = -g_m R_c$$

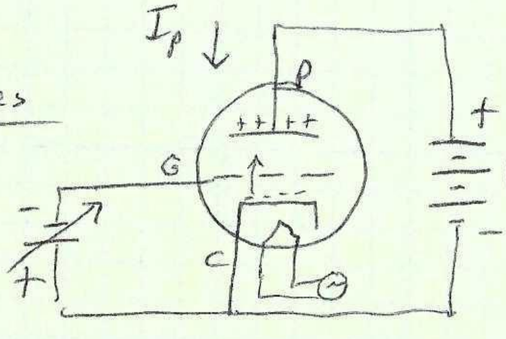
# Practical Designs (BJT Used Here)

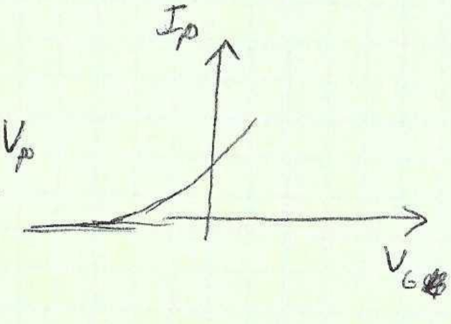
- Bias transistors in "active region"
  - BE forward biased
  - CB reverse biased "(or at least not forward)"
- AC Couple input & output signals



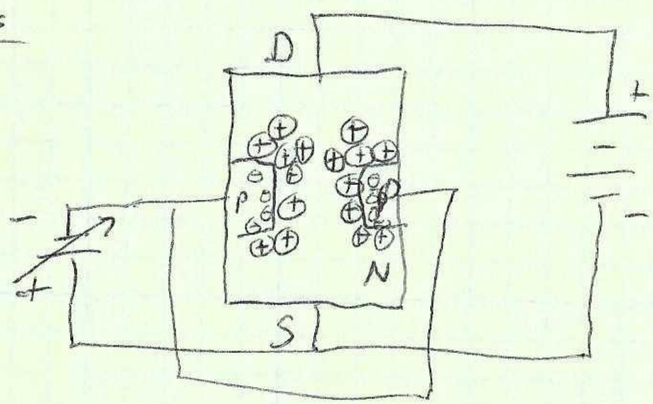
# Triodes

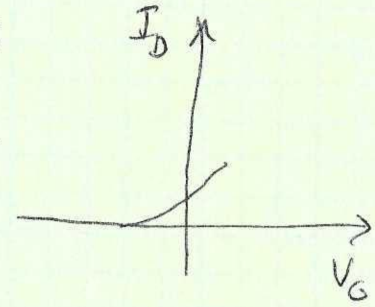
## Vaccum Tubes




## JFETs

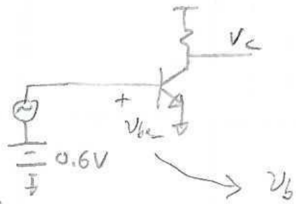



Control terminal (voltage) varies current through device :)

## Review

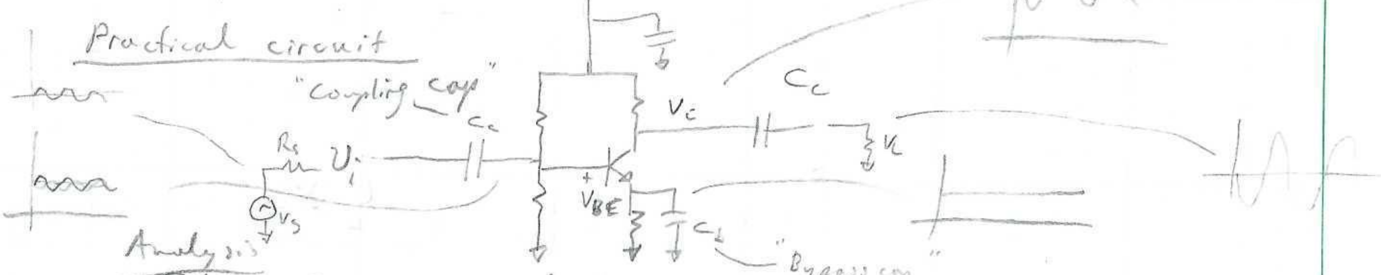
Recall basic CE amplifier concept: $v_s$




Forward bias BE junction, Reverse bias CB junction
wiggle $V_{BE}$ w/ $v_s$
$\Rightarrow \Delta I_c \Rightarrow \Delta V_c$

$v_{be} = 0.6 + v_s$

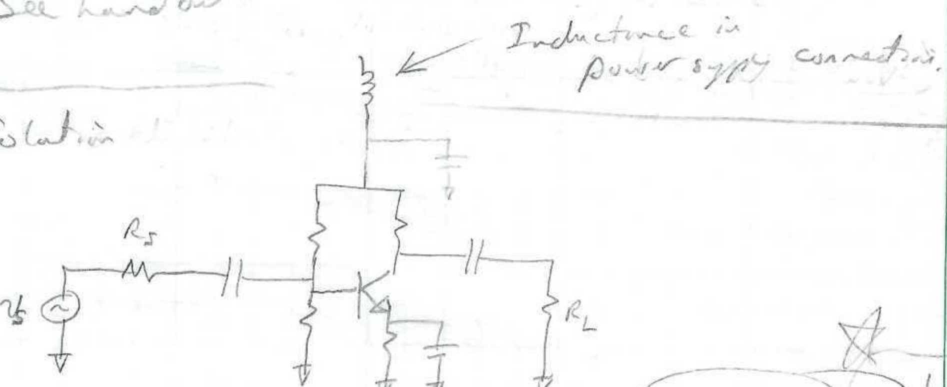
Practical circuit



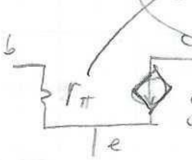

Analysis
Solve DC Bias w/ AC signal set to zero, capacitors open.
Solve AC ckt w/ DC sources at zero
Add solutions.
] Superposition

DC Solution - See handout

AC Solution



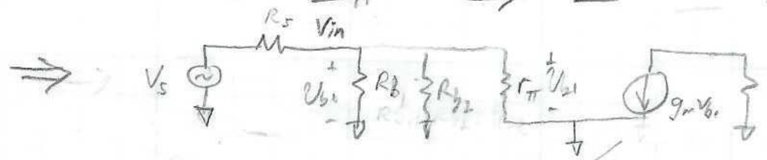

AC circuit:
$V_{cc} \rightarrow 0,$ ⏚
transistor $\rightarrow$
capacitor $\xrightarrow{\text{if big}}$ —




OR $h_{ie} = h_{fe} \frac{1}{g_m} = r_\pi$

$g_m = \frac{I_c}{n V_T}$

1.5 for 5179 device




$$V_L = (-g_m V_{be})(R_c \| R_L)$$

$$= \underbrace{V_S \frac{R_{in}}{R_{in}+R_s}}_{V_{in}} \left(-g_m (R_c \| R_L)\right)$$

Go over example

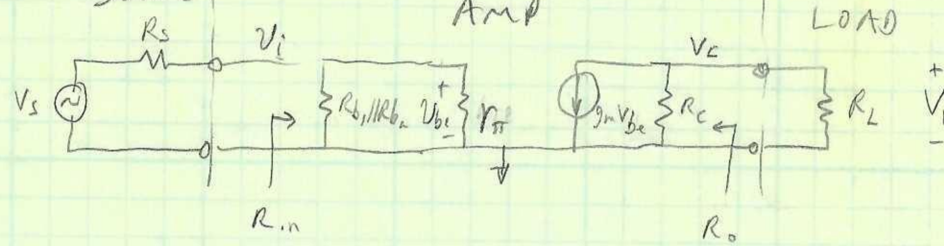
$R_{in} = R_{b1} \| R_{b2} \| r_\pi$

$A_V = \frac{V_L}{V_s} =$ fcn of $R_s$, $R_L$ !

# AC Ckt Solution Continued

## Input / Output Z, Unloaded & Loaded $A_V$

Separate amp from Source/Load ckts



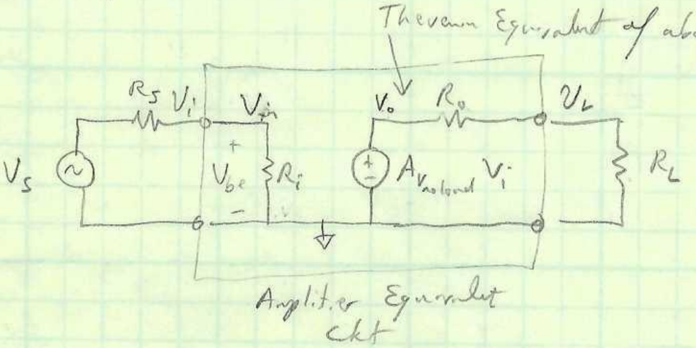

Consider Amp in isolation and characterize by

$$R_{in} = R_{b_1} || R_{b_2} || r_\pi$$

$$R_o = R_c \quad \text{"(set independent sources to zero)"}$$

$$A_{V_{no\,load}} = \left.\frac{V_c}{V_i}\right|_{R_L \to \infty} = \frac{-(g_m V_i) R_c}{V_{be}} = -g_m R_c$$

Now Consider Loading Effects:




$$A_V \triangleq \frac{V_L}{V_S} = \frac{V_{in}}{V_S} \frac{V_o}{V_{in}} \frac{V_L}{V_o}$$

$$= \left(\frac{R_i}{R_i + R_S}\right) A_{V_{no\,load}} \left(\frac{R_L}{R_o + R_L}\right)$$

$$= (\quad)(-g_m R_c)(\quad)$$

$$= -(\quad) g_m \left(\frac{R_c R_L}{R_c + R_L}\right)$$

$$= -\left(\frac{R_i}{R_i + R_S}\right) g_m (R_c || R_L)$$

Same as Before!