Spring 2019 Purdue University

ECE 255: L27

Preparation for Exam 3

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Announcements

1) HW8 solutions have been posted

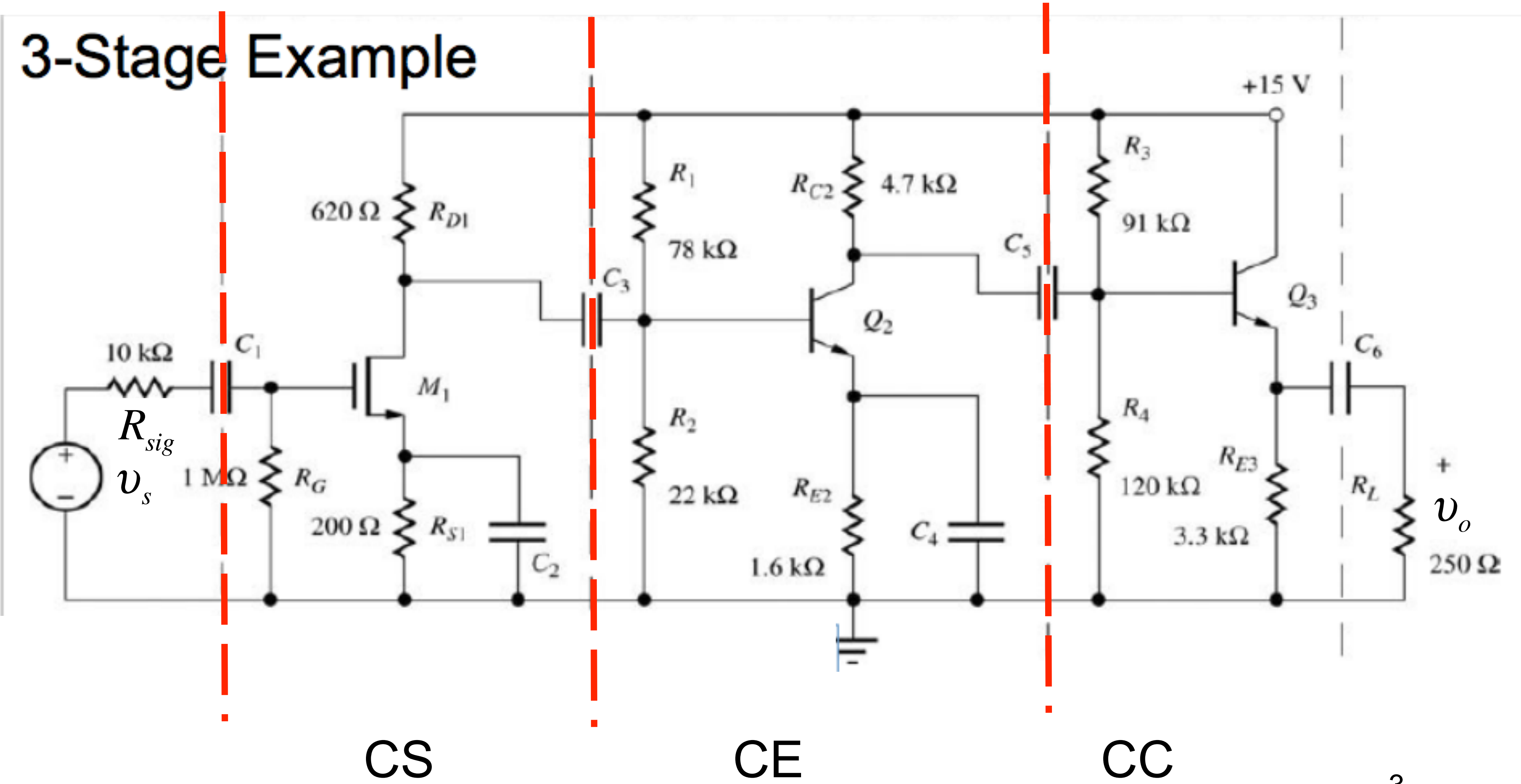
2) Exam 3 is at 6:30 PM, Tuesday, April 2

3) No class on Wed., April 3

4) Spice Project 3 will be due on April 17

5) Professor Janes will conduct a help session on Tuesday, 1:30 PM ME1061

Multi-stage amplifiers



Voltage gain

$$A_\upsilon = \frac{\upsilon_o}{\upsilon_s} = \frac{R_{in}}{R_{in}+R_{sig}} \times A_\upsilon\big)_{CS} \times A_\upsilon\big)_{CE} \times A_\upsilon\big)_{CD}$$

$$\frac{R_{in}}{R_{in}+R_{sig}} = \frac{R_G}{R_G+R_{sig}}$$

$$A_{CS} = -g_{m1}R_{D1} \parallel \left[\left(R_1 \parallel R_2\right) \parallel r_{\pi 2}\right]$$

$$A_{CE} = -g_{m2}R_{C2} \parallel \left[\left(R_3 \parallel R_4\right) \parallel \left\{r_{\pi 3} + (\beta+1)\left(R_{E3} \parallel R_L\right)\right\}\right]$$

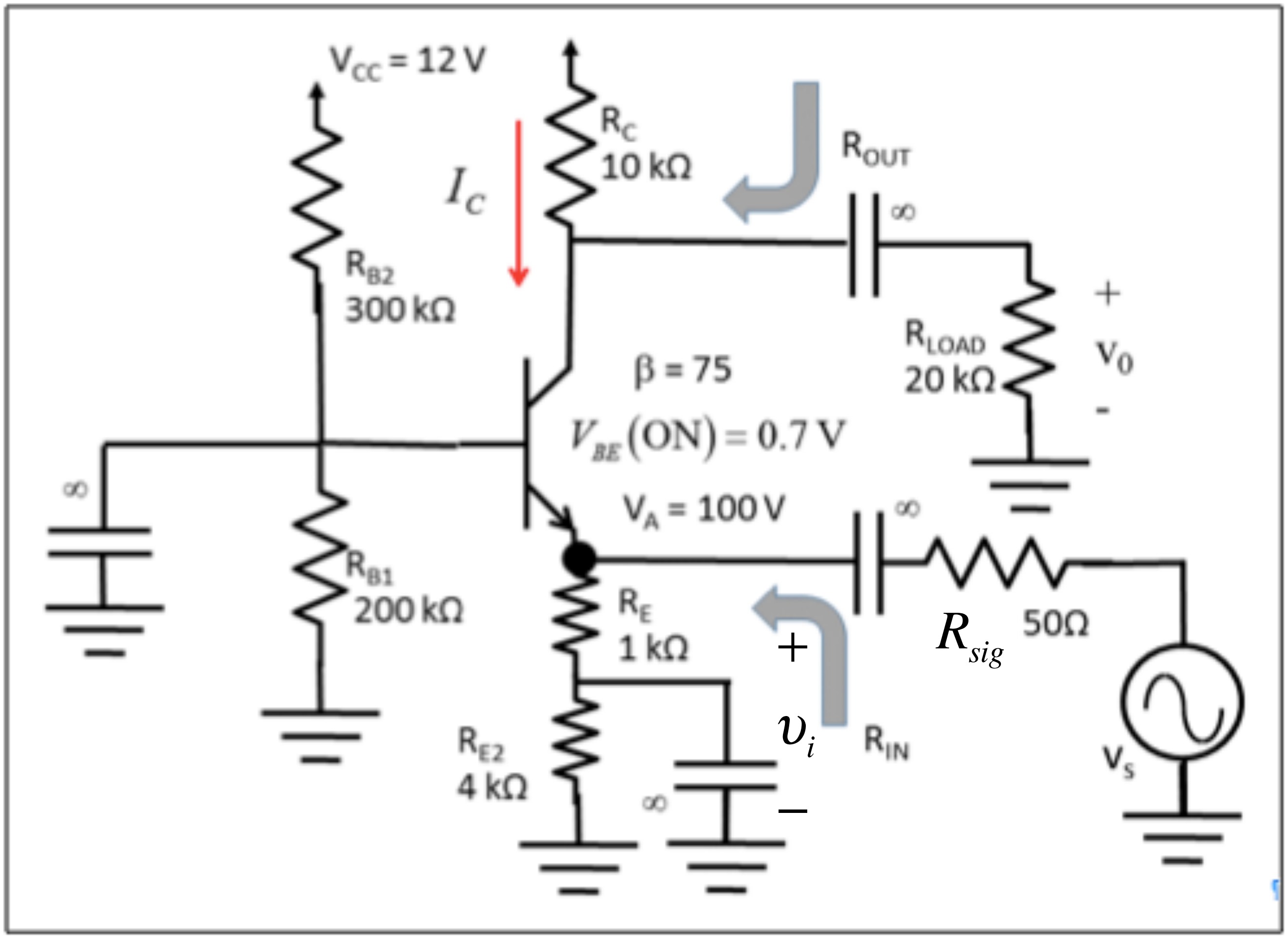
$$A_{CC} = \frac{(\beta+1)\left(R_{E3} \parallel R_L\right)}{r_{\pi 3} + (\beta+1)\left(R_{E3} \parallel R_L\right)}$$

Input and output resistance

$$R_{in} = R_G$$

$$R_{out} = R_{E3} \parallel \left[\frac{r_{\pi 3} + \left(R_3 \parallel R_4 \right) \parallel R_{C2}}{\beta + 1} \right]$$

HW7 Problem 1



HW1 Prob. 1

R_{in}

R_{out}

First, assume that ro is infinite

$A_{v_i} = \frac{v_o}{v_i}$

Can you see that A_{vi} ~ 10?

$A_{v_s} = \frac{v_o}{v_s}$

HW1 Prob. 1

$$R_{in} = R_E \parallel \frac{r_\pi}{\beta + 1}$$

$$R_{out} = R_C$$

First, assume that ro is infinite

$$A_{\upsilon_s} = \frac{\upsilon_o}{\upsilon_s} = \frac{R_{in}}{R_{in} + R_{sig}} \times \frac{r_\pi}{r_\pi + (\beta + 1) R_E} \left(-g_m R_C \parallel R_L \right)$$

HW1 Prob. 1

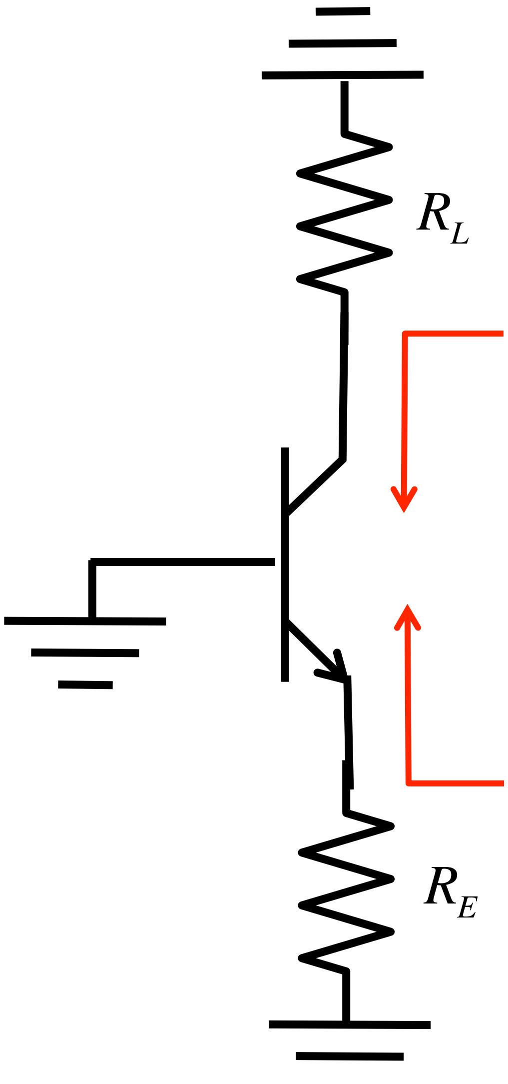
$$R_{in} = R_E \parallel \frac{r_\pi}{\beta+1} \rightarrow ?$$

$$R_{out} = R_C \rightarrow ?$$

Now include ro

$$A_{\upsilon_s} = \frac{\upsilon_o}{\upsilon_s} = \frac{R_{in}}{R_{in}+R_{sig}} \times \frac{r_\pi}{r_\pi + (\beta+1)R_E}\left(-g_m R_C \parallel R_{LOAD}\right) \rightarrow ?$$

HW 7 #1 with r_o



$$R_{out} \approx r_o + (g_m r_o)(R_E \parallel r_\pi)$$

$$R_{in} \approx \frac{r_\pi}{\beta + 1} + \frac{R_L}{g_m r_o}$$

HW1 Prob. 1

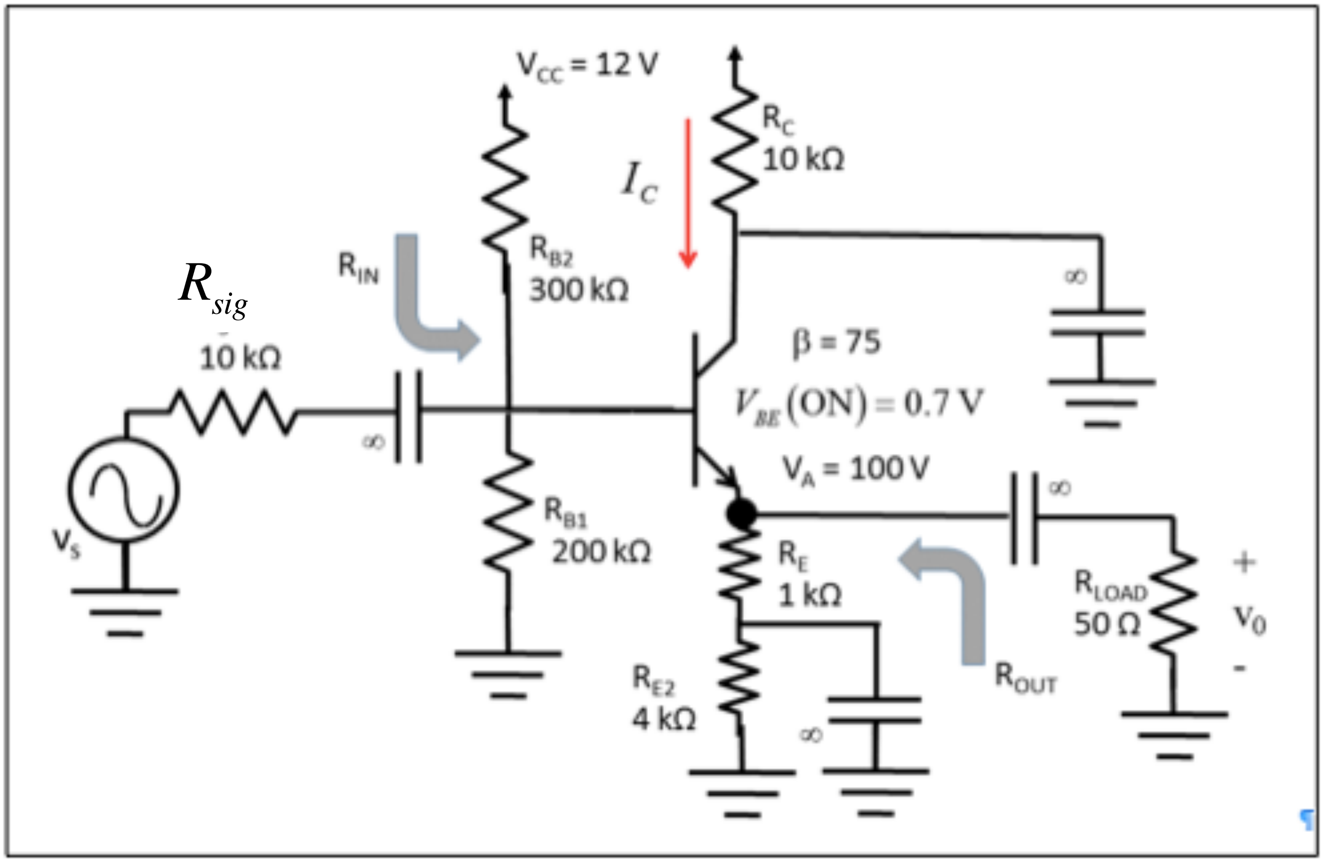
$$R_{in} = R_E \parallel \frac{r_\pi}{\beta+1} \rightarrow R_E \parallel \left[\frac{r_\pi}{\beta+1} + \frac{R_C \parallel R_{LOAD}}{g_m r_o} \right] \approx R_E \parallel \frac{r_\pi}{\beta+1}$$

$$R_{out} = R_C \rightarrow R_C \parallel \left[r_o + g_m r_o \left(R_E \parallel R_{sig} \parallel r_\pi \right) \right] \approx R_C$$

$$A_{\upsilon_s} = \frac{\upsilon_o}{\upsilon_s} = \frac{R_{in}}{R_{in} + R_{sig}} \times \frac{r_\pi}{r_\pi + (\beta+1) R_E} \left(-g_m R_C \parallel R_{LOAD} \right) \rightarrow$$

$$\frac{R_{in}}{R_{in} + R_{sig}} \times \frac{r_\pi}{r_\pi + (\beta+1) R_E} \left(-g_m R_C \parallel \left[r_o + g_m r_o \left(R_E \parallel R_{sig} \parallel r_\pi \right) \right] \parallel R_{LOAD} \right)$$

HW7 #2



V_CC = 12 V
R_C
10 kΩ
I_C
R_IN
R_B2
300 kΩ
R_sig
10 kΩ
β = 75
V_BE(ON) = 0.7 V
V_A = 100 V
∞
V_S
R_B1
200 kΩ
R_E
1 kΩ
R_E2
4 kΩ
R_LOAD
50 Ω
R_OUT
+
V_O
-

HW7 #2

R_{in}

R_{out}

Assume that ro is **finite**

$$A_{\upsilon_s} = \frac{\upsilon_o}{\upsilon_s}$$

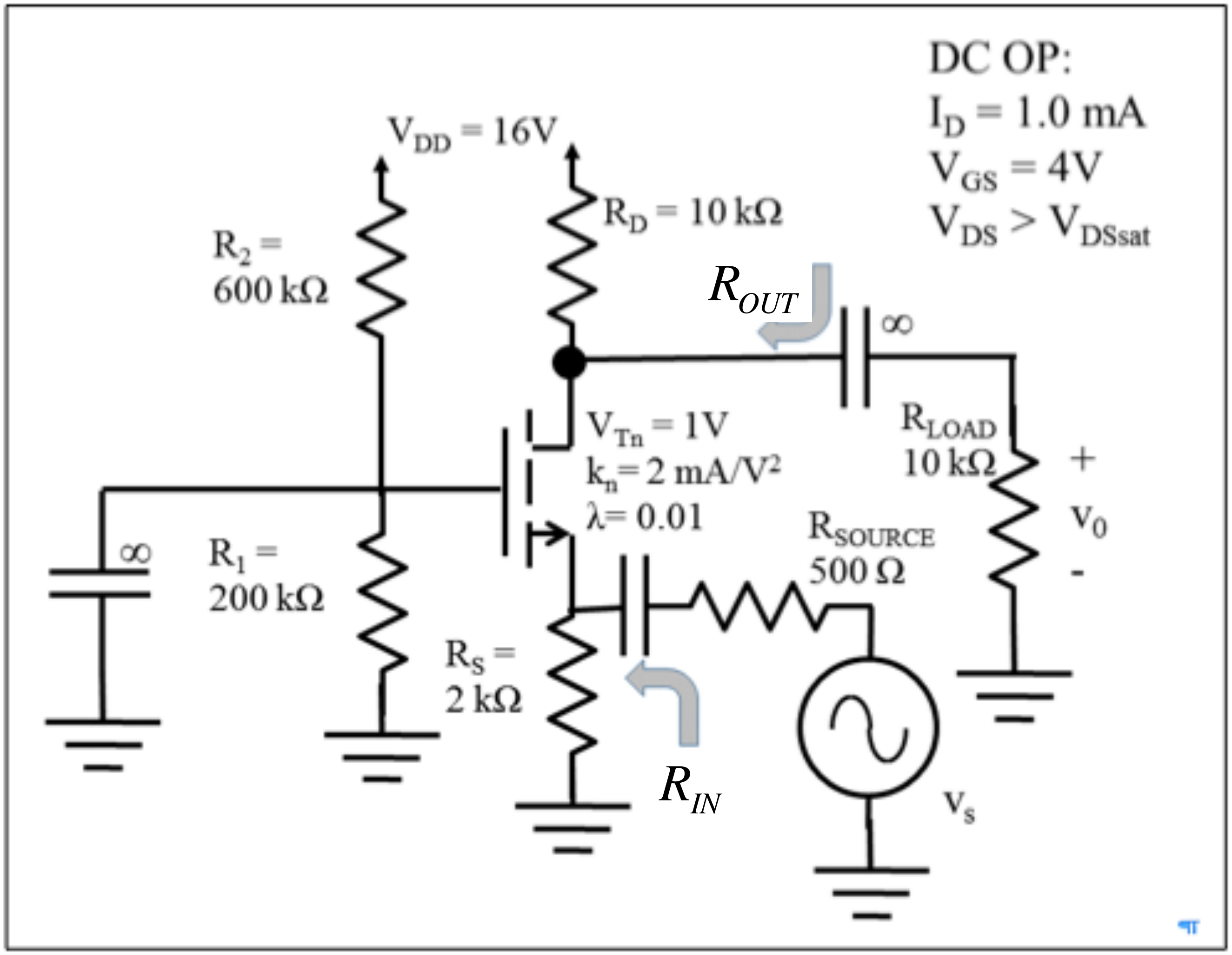
HW7 #2

$$R_{in} = R_{B1} \parallel R_{B2} \parallel \left[r_\pi + (\beta + 1)(R_E \parallel R_{LOAD} \parallel r_o) \right]$$

$$R_{out} = R_E \parallel r_o \parallel \frac{r_\pi + R_{sig} \parallel (R_{B1} \parallel R_{B2})}{\beta + 1}$$

$$A_{\upsilon_s} = \frac{\upsilon_o}{\upsilon_s} = \frac{R_{in}}{R_{in} + R_{sig}} \times \frac{(\beta + 1) R_E \parallel r_o \parallel R_{LOAD}}{r_\pi + (\beta + 1) R_E \parallel r_o \parallel R_{LOAD}}$$

HW7 #3



DC OP:
I_D = 1.0 mA
V_{GS} = 4V
$V_{DS} > V_{DSsat}$
V_{DD} = 16V
R_2 = 600 kΩ
R_D = 10 kΩ
R_{OUT}
∞
V_{Tn} = 1V
k_n= 2 mA/V²
λ= 0.01
R_{LOAD} 10 kΩ
+
v_0
-
∞
R_1 = 200 kΩ
R_{SOURCE} 500 Ω
R_S = 2 kΩ
R_{IN}
v_s

HW7 #3 with ro infinite

R_{in}

R_{out}

Assume that ro is **infinite**

$$A_{v_s} = \frac{v_o}{v_s}$$

HW7 #3 with ro finite

R_{in}

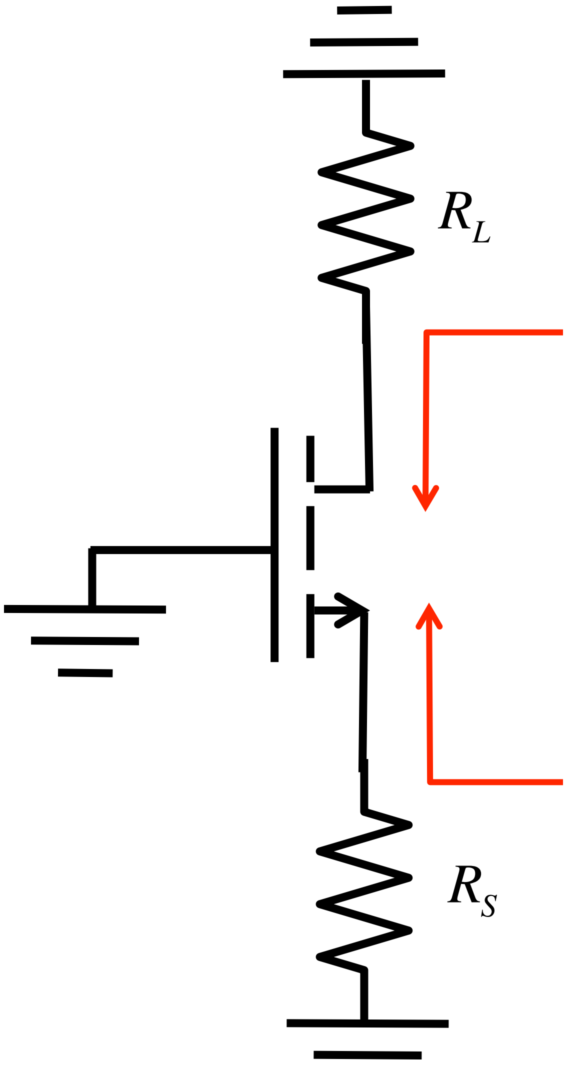
R_{out}

$A_{\upsilon_s} = \frac{\upsilon_o}{\upsilon_s}$

Assume that r_o is **finite**

(left as an exercise)

HW7 #3 with ro



$$R_{out} \approx r_o + \left(g_m r_o\right) R_S$$

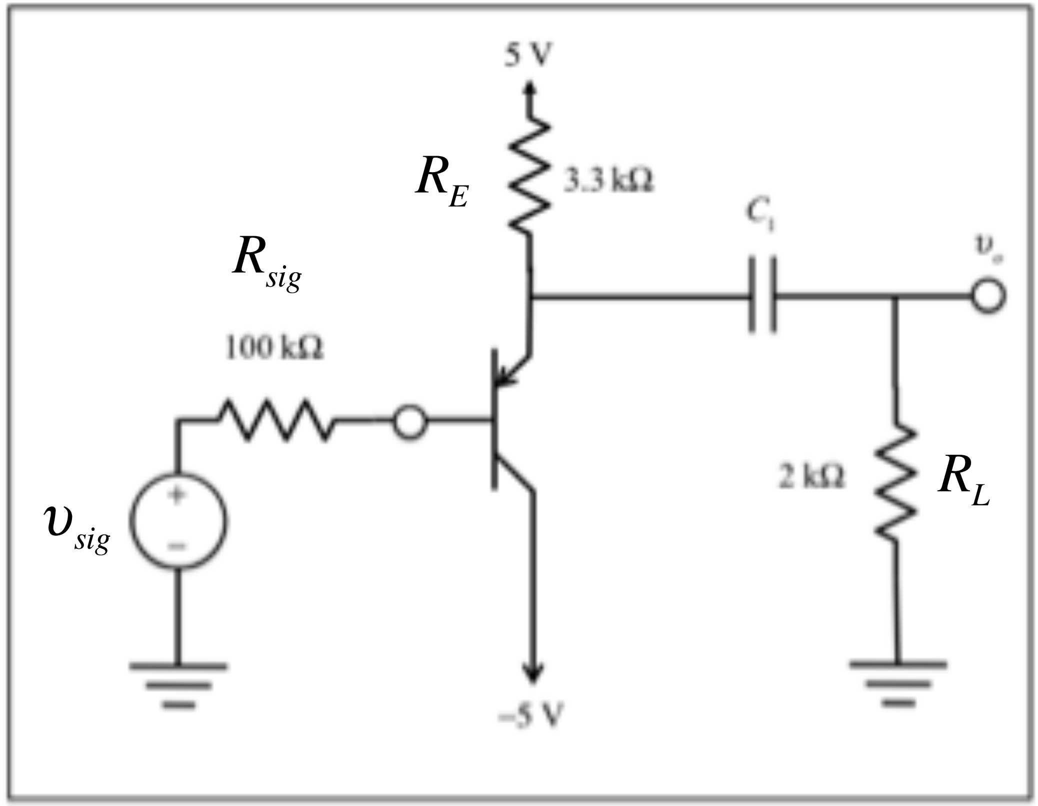
$$R_{in} \approx \frac{1}{g_m} + \frac{R_L}{g_m r_o}$$

HW7 #4 r_o infinite

$R_{in} = ?$

$R_{out} = ?$

$A_{v_s} = \frac{v_o}{v_s} = ?$

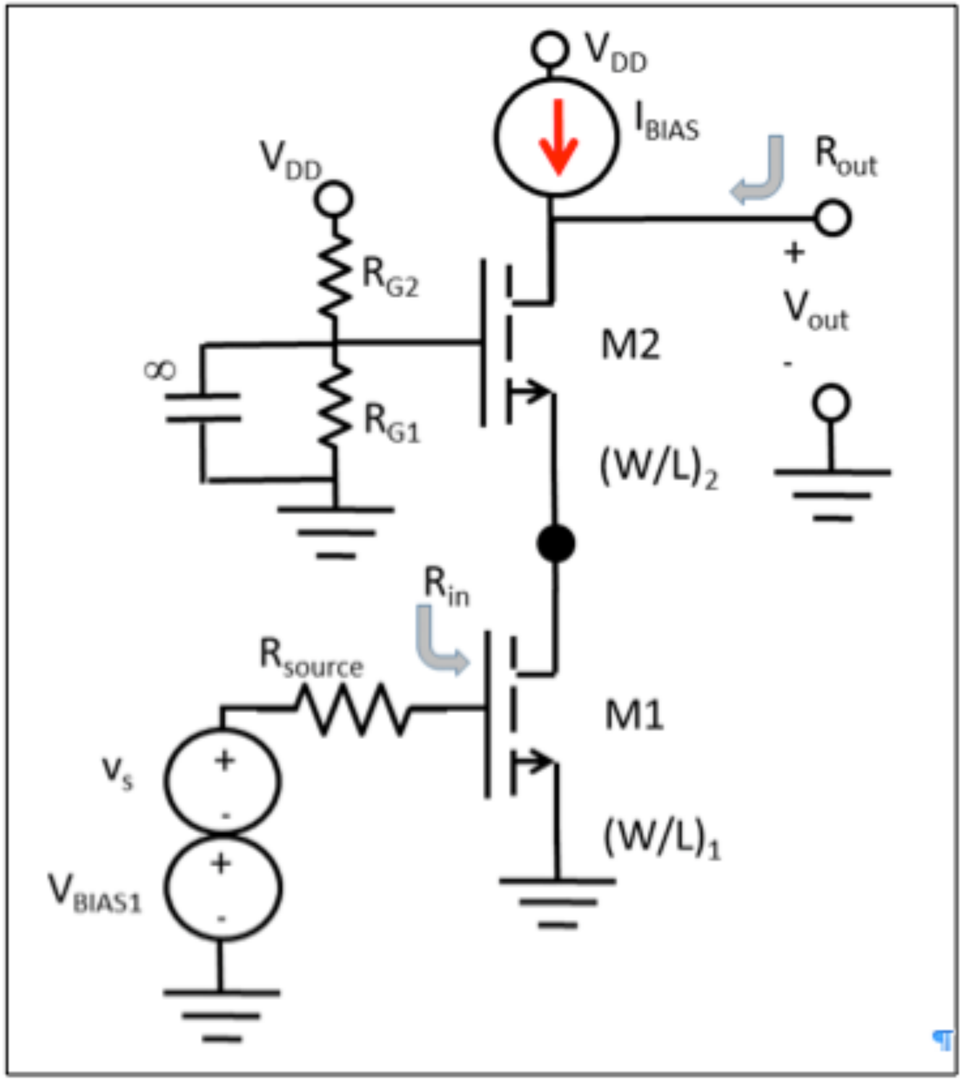


HW8 #5 include r_o

$$R_{in} = ?$$

$$R_{out} = ?$$

$$A_{\upsilon_s} = \frac{\upsilon_o}{\upsilon_s} = ?$$



HW8 #5 include r_o

$$R_{in} = \infty$$

$$R_{out} = r_{o2} + \left(g_{m2} r_{o2}\right) r_{o3}$$

$$A_{\upsilon_s} = \frac{\upsilon_o}{\upsilon_s} = -g_{m1} R_{OUT}$$

$$r_o = 100\ \mathrm{k}\Omega$$

$$g_m = 2\ \mathrm{mS}$$

$$R_{out} = 100 + \left(200\right)100 = 20.1\ \mathrm{M}\Omega$$

$$A_{\upsilon_s} = -40{,}100$$