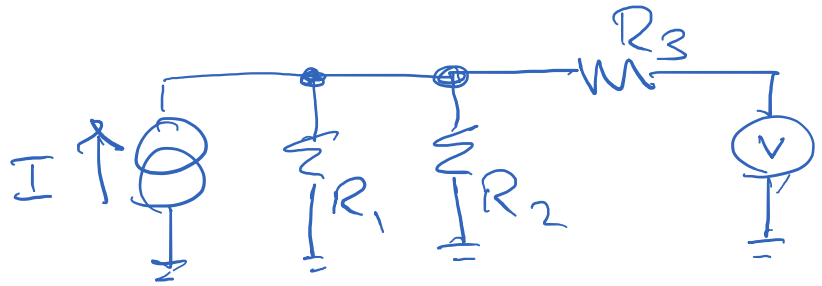
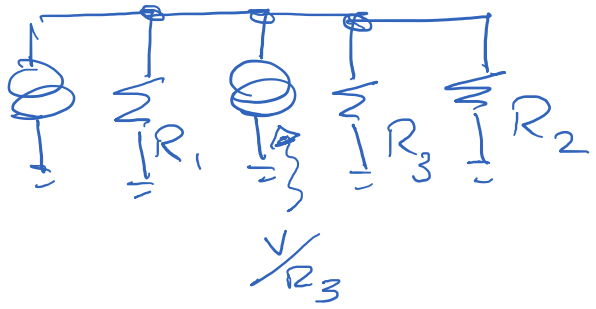
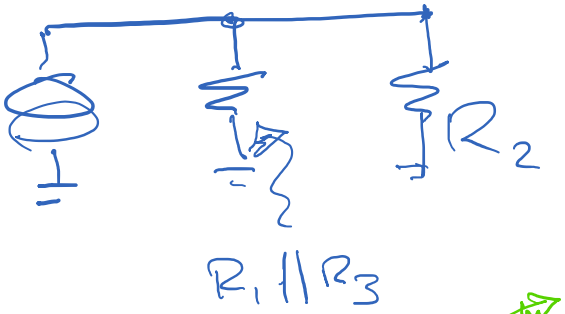
Midterm Solutions

① 

$\Rightarrow$ 

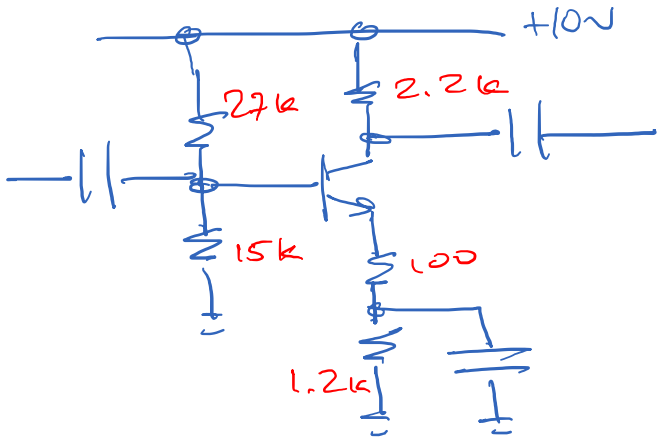
$\Rightarrow$ 

$$\therefore I(R_2) = \frac{R_1 \| R_3}{R_1 \| R_3 + R_2}\left[I + \frac{V}{R_3}\right]$$

CURRENT DIVIDER $\rightarrow$ $\therefore$

$$= \frac{R_1}{R_1R_2 + R_1R_3 + R_2R_3}\left[I + \frac{V}{R_3}\right]$$

(2)



A

$$V_B \approx 10V \times \frac{15k}{15k+27k} = 3.6V$$

[A MORE DETAILED CALCULATION THAT TAKES INTO ACCOUNT CURRENT DRAWN BY BASE YIELDS $V_B = 3.4V$]

$V_E = 3.6V - 0.6V = 3.0V \Rightarrow I_E \approx I_C = 2.3mA$

$V_C = 10V - (2.2k)(2.3mA) = 4.9V$

B

$R_{in} = 15k \,||\, 27k \,||\, R(\text{into base})$

$R(\text{into base})$?

@ SIGNAL FREQUENCIES,

HAVE $R_{DYN} \simeq \left(\frac{25}{2.3}\right)\Omega + 100\Omega \simeq 110\Omega$

FROM EMITTER TO GROUND

$R_{in} \simeq 15k \,||\, 27k \,||\, 11k$

$\simeq \underline{5.1k\Omega}$

C

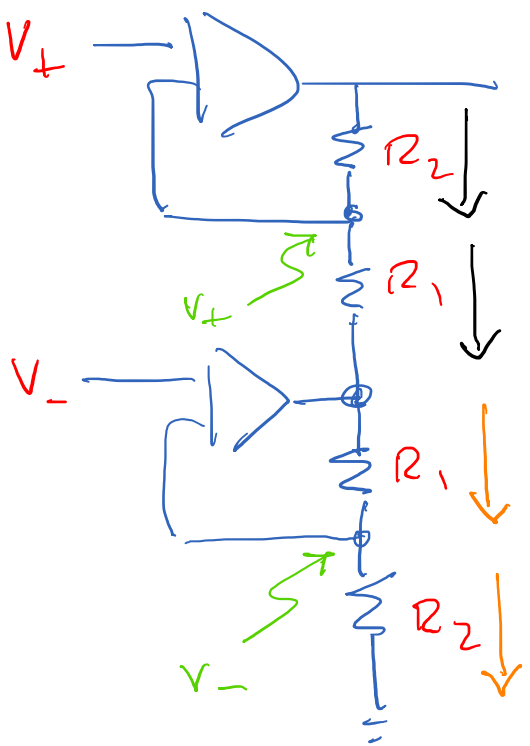
$R_{out} = R_C = 2.26\,k\Omega$

D

FOR SMALL SIGNALS, RESISTANCE FROM EMITTER TO GROUND IS $\sim 110\,\Omega$

$$A_V = -\frac{R_C}{R_{E,\,eff}} = -\frac{2.26}{110} = -20$$

(3)



CURRENTS IN BLACK ARE EQUAL

CURRENTS IN ORANGE ARE EQUAL

[OP. AMP INPUTS DRAW NO CURRENT]

- CURRENT THRU R_2 TO GROUND IS $\frac{V_-}{R_2}$
- VOLTAGE @ OUTPUT OF LOWER OP. AMP IS THEREFORE $V_- + \left(\frac{V_-}{R_2}\right) R_1$
- CURRENT THRU UPPER OP AMP IS $\frac{1}{R_1}\left[V_+ - \left(1 + \frac{R_1}{R_2}\right) V_-\right]$
- THIS SAME CURRENT FLOWS THRU UPPER RESISTOR R_2.

$$\therefore$$

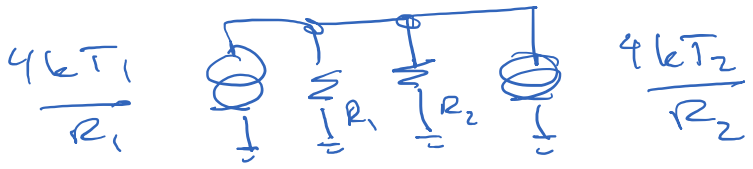
$$V_{out} = V_+ + \frac{R_2}{R_1}\left[V_+ - \left(1 + \frac{R_1}{R_2}\right) V_-\right]$$

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

$$A_{CM} = 0 \; ; \; A_D = 1 + \frac{R_2}{R_1}$$

(4)

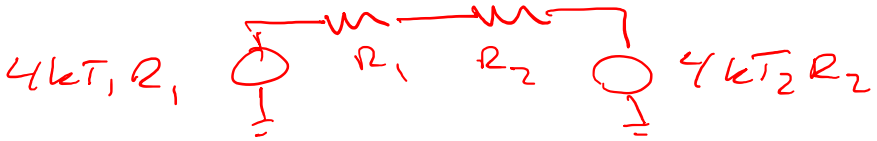
A. VOLTAGE NOISE?



$$S_V = 4k\left[\frac{T_1}{R_1} + \frac{T_2}{R_2}\right](R_1 \| R_2)^2$$

$$= 4k\left[T_1R_2 + T_2R_1\right]\left[\frac{R_1R_2}{(R_1+R_2)^2}\right]$$

B. CURRENT NOISE?



$$S_I = \frac{4k(T_1R_1 + T_2R_2)}{(R_1+R_2)^2}$$