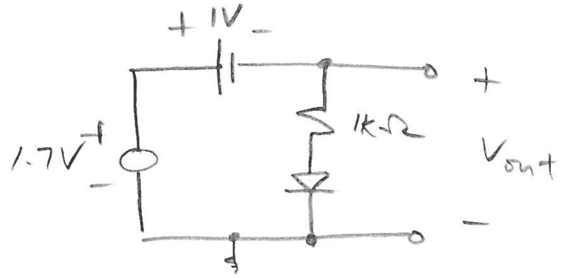
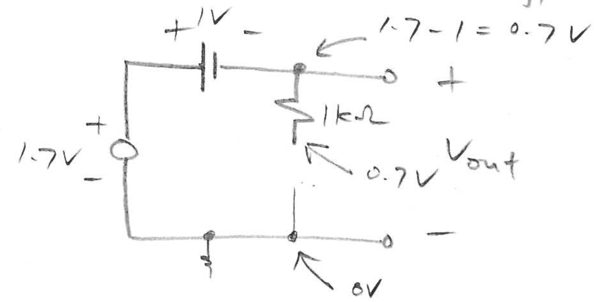
1. Find V_{out}. $V_{D,on} = 0.8V$



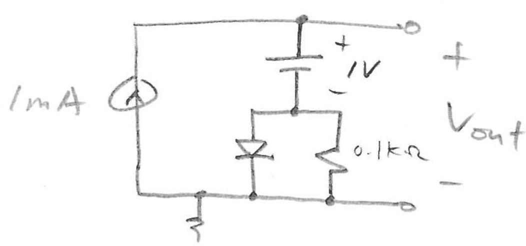
Assume the diode is off



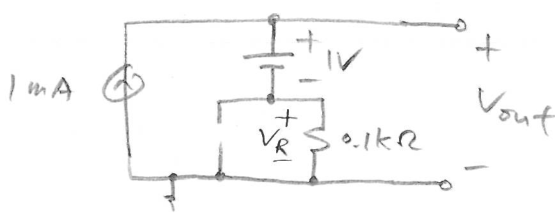
The volt. across the diode < $V_{D,on}$ → assumption correct.

→ $V_{out} = 0.7V$

2. Find V_{out}. $V_{D,on} = 0.8V$



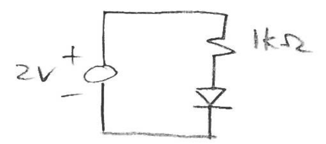
Assume the diode is off



$V_R = 1mA \times 0.1k\Omega = 0.1V < V_{D,on}$ → assumption correct

$V_{out} = 0.1 + 1 = 1.1V$

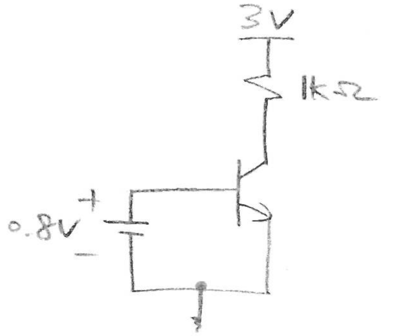
3. Assume the volt. across the diode when it is on is 0.8V. Find I_S.



$$I_D = I_S e^{V_D/V_T} = \frac{2-0.8}{1k} = 1.2\,mA$$

$$I_S = \frac{1.2m}{e^{0.8/26m}} = 5.2 \times 10^{-17}\,A$$

4. Find I_S such that the transistor is at the edge of sat.



At the edge when $V_{CE} = V_{BE} = 0.8V$

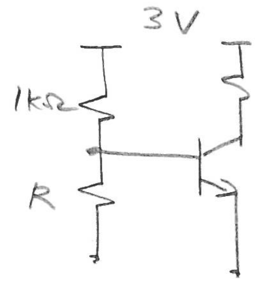
$V_{CE} = 3V - I_c \times 1k$

$I_C = I_S e^{V_{BE}/V_T}$

$0.8 = 3 - I_S e^{V_{BE}/V_T} \times 1k$

$$I_S = \frac{3-0.8}{e^{0.8/26m} \times 1k} = 9.54 \times 10^{-17}\,A$$

5. Find R. $I_S = 10^{-17}$, $I_C = 1mA$.



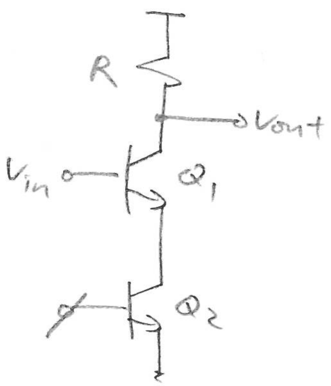
$$V_{BE} = V_T \ln \frac{I_C}{I_S} = 0.838 \text{ V}$$

$$V_{BE} = 3 \times \frac{R}{R + 1k} = 0.838$$

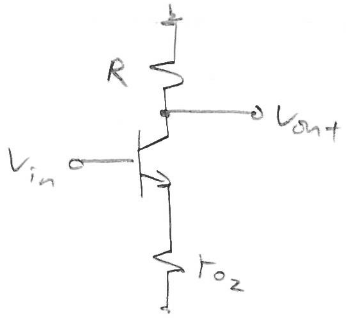
$$3R = 0.838R + 838$$

$$R = 388\ \Omega$$

6. Find gain. $V_{A_1} = \infty$, $V_{A_2} \neq \infty$.

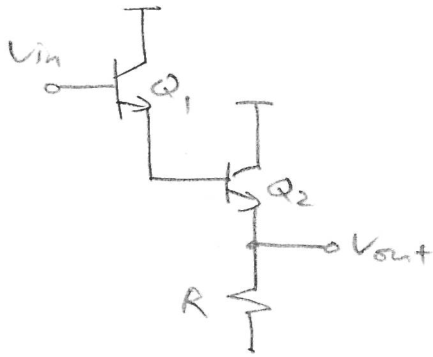


S.S.

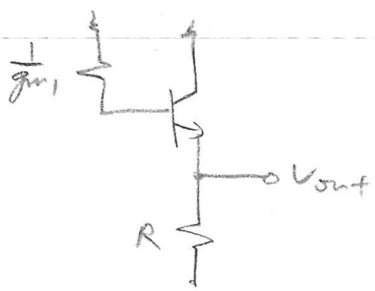


$$\frac{V_{out}}{V_{in}} = \frac{-g_{m_1} R}{1 + g_{m_1} r_{o2}}$$

7. Find R_{out}. $V_A = \infty$



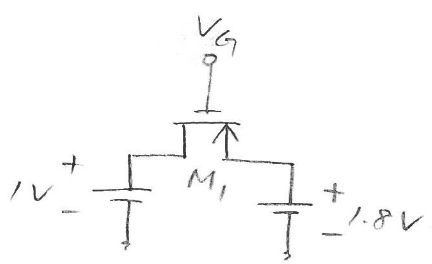
S.S.



From table:

$$R_{out} = \left(\frac{1}{g_{m2}} + \frac{1/g_{m1}}{\beta_2}\right) \parallel R$$

8. What V_G is needed to bias M_1 at the edge of sat.? $V_{th} = 0.5V$



M_1 is PMOS

At edge when $V_{SD} = V_{SG} - V_{th}$

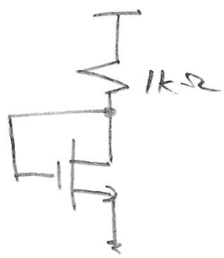
$$V_{SD} = V_S - V_G - V_{th}$$

$$V_G = V_S - V_{th} - V_{SD}$$

$$= 1.8 - 0.5 - (1.8 - 1)$$

$$= 0.5\ V$$

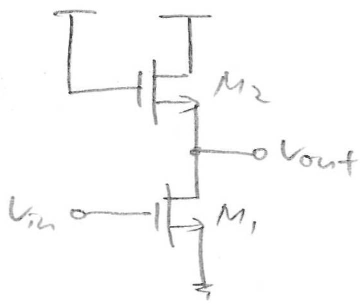
9. Find $\frac{W}{L}$. $I_D = 1mA$, $\mu C_{ox} = 200 \mu A/V^2$, $V_{th} = 0.5V$



$$V_{GS} = 1.8V - 1mA \times 1k\Omega = 0.8V$$

$$\frac{W}{L} = \frac{I_D}{\frac{1}{2}\mu C_{ox}(V_{GS} - V_{th})^2} = \frac{1m}{\frac{1}{2} 200\mu (0.8 - 0.5)^2} = 111$$

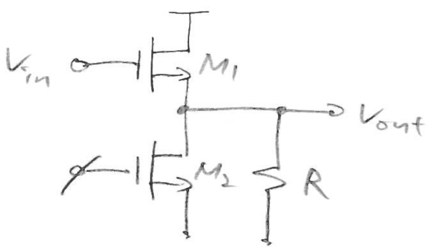
10. Find gain. $\left(\frac{W}{L}\right)_1 = 100$, $\left(\frac{W}{L}\right)_2 = 1$, $\lambda = 0$.



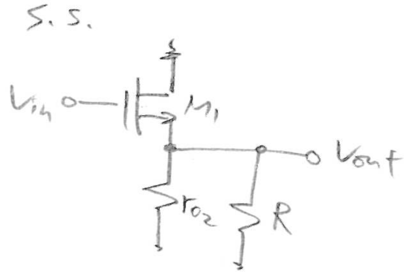
$$\frac{V_{out}}{V_{in}} = -g_{m1} \times \frac{1}{g_{m2}} = -\frac{\sqrt{2\mu C_{ox}\left(\frac{W}{L}\right)_1 I_D}}{\sqrt{2\mu C_{ox}\left(\frac{W}{L}\right)_2 I_D}} = -\sqrt{\frac{\left(\frac{W}{L}\right)_1}{\left(\frac{W}{L}\right)_2}} = -10$$

$$g_m = \sqrt{2\mu C_{ox}\frac{W}{L} I_D}$$

11. Find gain. $\lambda_1 = 0$, $\lambda_2 \neq 0$.



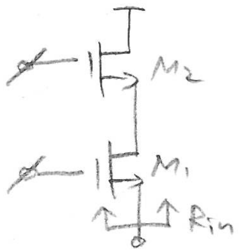
S.S.



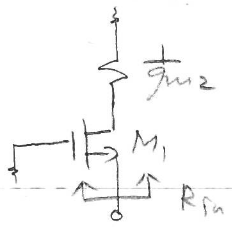
From table:

$$\frac{V_{out}}{V_{in}} = \frac{-g_{m1}(r_{o2} \| R)}{1 + g_{m1}(r_{o2} \| R)}$$

12. Find R_{in}. $\lambda_1 \neq 0$, $\lambda_2 = 0$.

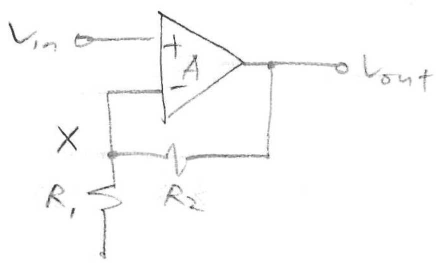


s.s.



$$R_{in} = \frac{\frac{1}{g_{m2}} + r_{o1}}{1 + g_{m1} r_{o1}}$$

13. Find gain. $A = 1000$, $R_1 = 1k\Omega$, $R_2 = 9\,k\Omega$.



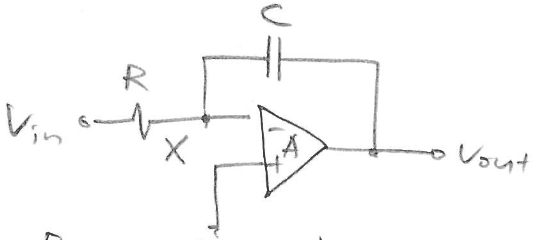
$$V_x = V_{out} \frac{R_1}{R_1 + R_2}$$

$$V_{out} = A\,(V_{in} - V_x) = A\left(V_{in} - V_{out}\frac{R_1}{R_1+R_2}\right)$$

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

$$\frac{V_{out}}{V_{in}} = \frac{A}{1 + A\frac{R_1}{R_1+R_2}} = \frac{1000}{1 + 1000\frac{1k}{1k+9k}} = 9.9$$

14. Find Vout. $V_{in} = V_0 \sin(t)$, $A = \infty$.



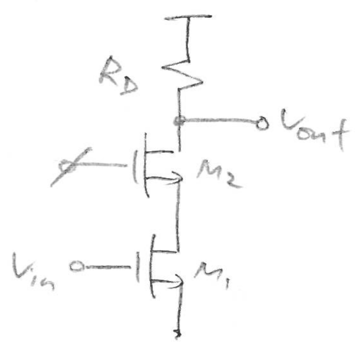
Because $A = \infty$, $V_x = 0\,V$.
KCL @ X

$$\frac{V_{in}}{R} + C\frac{dV_{out}}{dt} = 0$$

$$dV_{out} = -\frac{V_{in}}{RC}\,dt$$

$$V_{out} = \frac{-1}{RC}\int V_{in}\,dt = \frac{1}{RC}\cos(t)$$

15. Find gain. $\lambda \neq 0$.

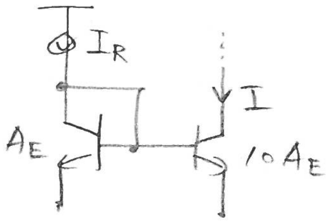


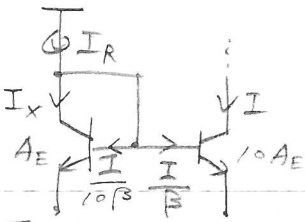
$$\frac{V_{out}}{V_{in}} = -G_m R_{out} = -g_{m1}(R_D \,\|\, g_{m2} r_{o2} r_{o1})$$

$G_m \simeq g_{m1}$

$R_{out} \simeq R_D \,\|\, g_{m2} r_{o2} r_{o1}$

16. Find I. $I_R = 1\,mA$, $\beta = 100$.





$I = 10\,I_x$

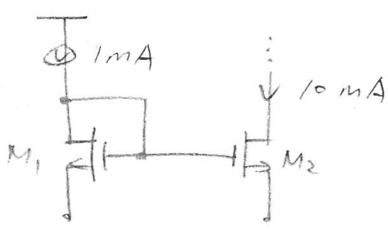
$I_x = I_R - \frac{I}{10\beta} - \frac{I}{\beta}$

$I = 10I_R - \frac{I}{\beta} - 10\frac{I}{\beta}$

$I\left(1 + \frac{10}{\beta}\right) = 10\,I_R$

$I = \frac{10}{1+\frac{10}{\beta}}\,I_R = 9.09\,mA$

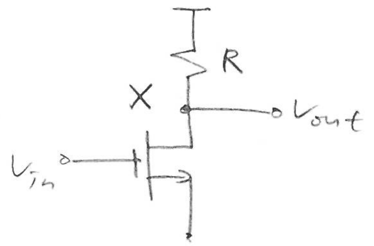
17. Find L_2. $\left(\frac{W}{L}\right)_1 = 10$, $W_2 = 20\,\mu m$



$$\frac{\left(\frac{W}{L}\right)_2}{\left(\frac{W}{L}\right)_1} = \frac{10m}{1m}$$

$$\frac{W_2}{\left(\frac{W}{L}\right)_1} \times \frac{1m}{10m} = L_2 = 0.2\,\mu m.$$

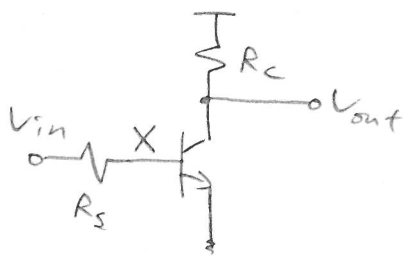
18. Find ω_{p_X}. $R = 1k\Omega$, $r_o = 20k\Omega$, $C_{GS} = 10fF$, $C_{GD} = 0fF$, $C_{SB} = C_{DB} = 2fF$.



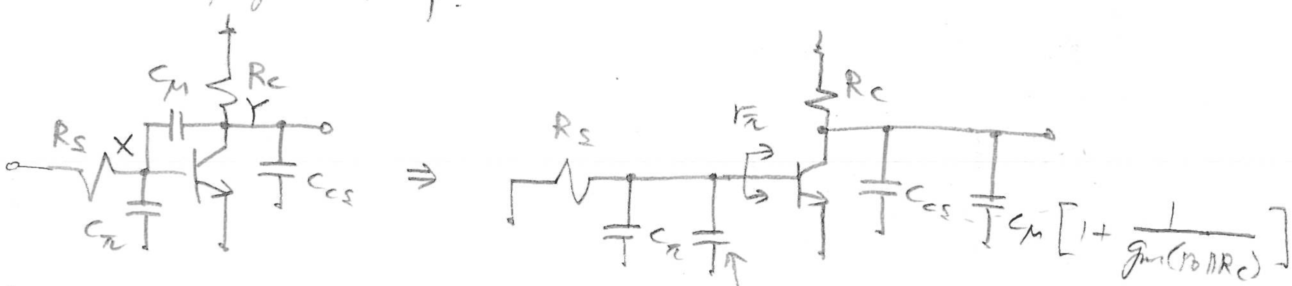
S.S., ground i/p.

$$\omega_{p_X} = \frac{1}{(R \| r_o) C_{DB}} = 5.25 \times 10^{11} \text{ rad/s}$$

19. Find ω_{p_X} using Miller's theorem. $g_m = 1mS$, $r_o = 20k\Omega$, $r_\pi = 100k\Omega$, $R_S = 50\Omega$, $R_C = 10k\Omega$, $C_\pi = 10fF$, $C_\mu = 20fF$, $C_{CS} = 40fF$.



S.S., Miller's, ground i/p.



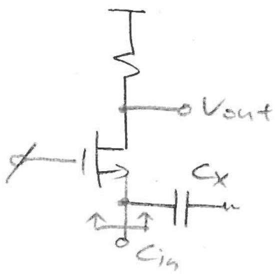
gain X to Y $= -g_m(r_o \| R_C) = -6.667$ $\quad C_\mu[1+g_m(r_o\|R_C)]$

$$\omega_{p_X} = \frac{1}{(R_S \| r_\pi)\{C_\pi + C_\mu[1+g_m(r_o\|R_C)]\}}$$

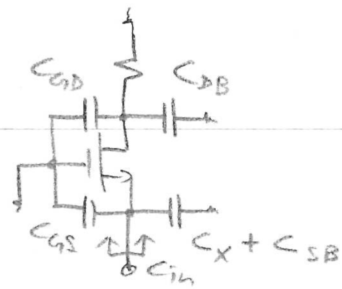
$$= \frac{1}{49.98\Omega \times 1.633 \times 10^{-13} F}$$

$$= 1.23 \times 10^{11} \text{ rad/s}$$

20. Find C_{in}.

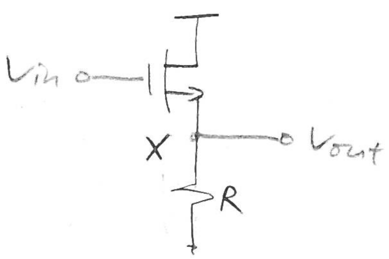


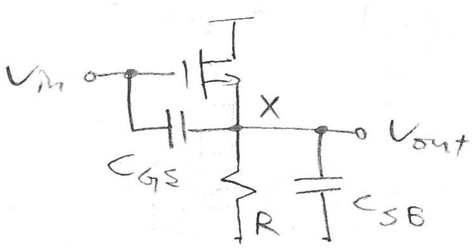
S.S., ground i/p.



$C_{in} = C_{GS} + C_X + C_{SB}$

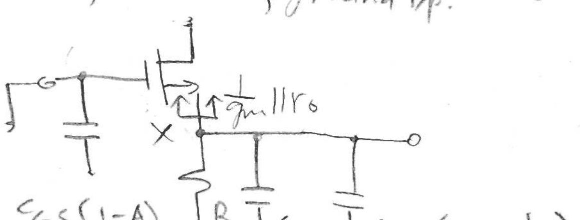
21. Find ω_{p_X}. Use Miller's. $\lambda \neq 0$.





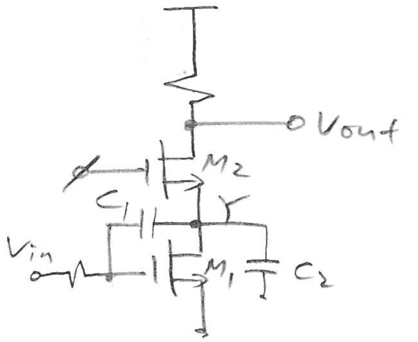
gain from V_{in} to X is $\dfrac{g_m r_o R}{R + r_o + g_m r_o R} = A$ (from CD in table)

S.S., Miller's, ground i/p.

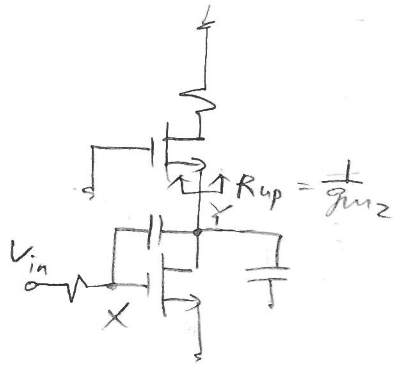


$$\omega_{p_X} = \frac{1}{\left(\frac{1}{g_m} \| r_o \| R\right)\left[C_{SB} + C_{GS}\left(1 - \frac{1}{A}\right)\right]}$$

22. Find the total cap. that Y sees to ground. Use Miller's. Ignore all parasitic caps. $\lambda = 0$.

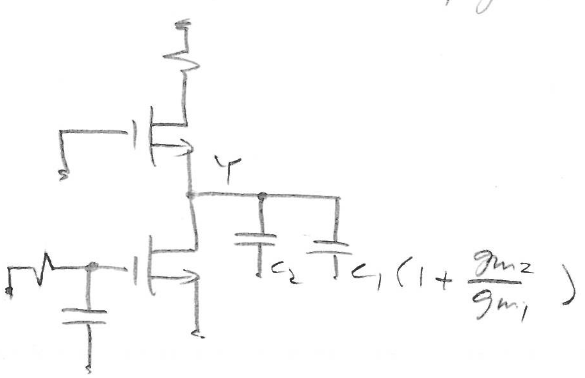


S.S.



gain X to Y $= -g_{m1}\frac{1}{g_{m2}}$

S.S., use Miller's, ground i/p.



$$C_Y = C_2 + C_1\left(1 + \frac{g_{m2}}{g_{m1}}\right)$$