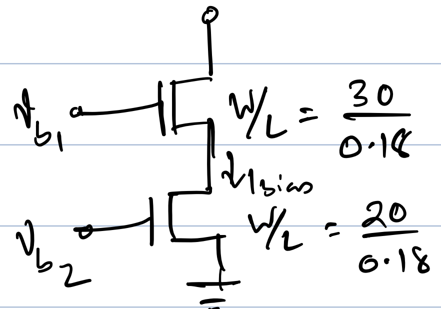
Solution - Mid-Sem Exam. Late

Q.1

(a)



$I_{bias} = 0.5\,mA$

$\mu_n C_{ox} = 100\,\mu A/V^2$

$V_{TH} = 0.4\,V$

$$I_{bias} = I_{D_2} = \frac{1}{2}\mu_n C_{ox}\left(\frac{W}{L}\right)_2 (V_{b_2} - V_{TH})^2$$

$$V_{b2} = \sqrt{\frac{2 I_{bias}}{\mu_n C_{ox}(W/L)_2}} + V_1$$

$$= \sqrt{\frac{2 \times (0.5\,mA)}{(100\,\mu A/V^2)\left(\frac{20}{0.18}\right)}} + 0.4$$

$$\simeq 0.7\,V$$

(b)

M_2 operates in saturation as long as

$$V_{GS2} - V_{th} \leq V_{DS2}$$

$$\therefore V_{DS_2} \geq 0.3\,V$$

Now $V_{GS_1} = V_{b_1} - V_{DS_2}$

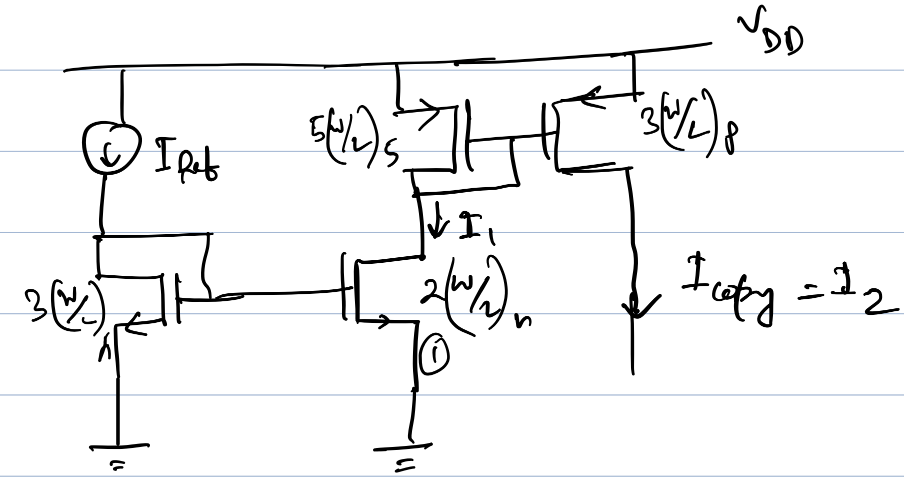
$$I_{D_1} = I_{Bias} = \frac{1}{2}\mu_n C_{ox}\left(\frac{W}{L}\right)_1 (V_{GS_1} - V_{th})^2$$

$$\Rightarrow V_{b1} \geq \sqrt{\frac{2 I_{bias}}{\mu_n C_{ox} W/L}} + 0.4\,V + 0.3\,V$$

$$\simeq 0.95\,V$$

$\therefore$ Minimum $V_{b1} = 0.95\,V$

2 (a)

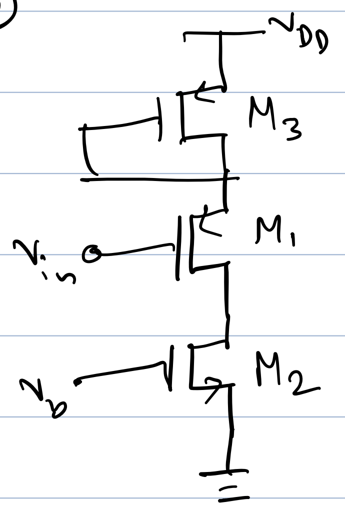


$$I_1 = \frac{2(W/L)_n}{3(W/L)_n} I_{ref} = \frac{2}{3} I_{ref}$$

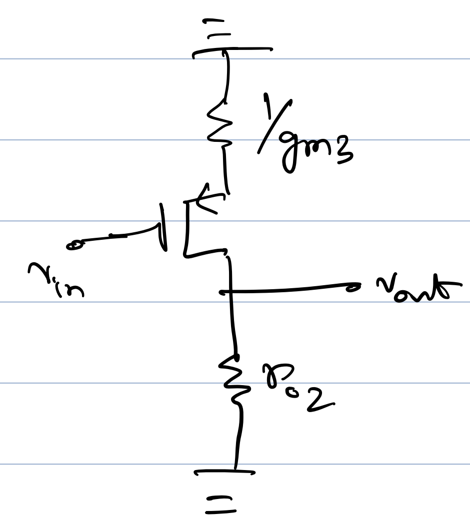
$$I_2 = \frac{3(W/L)_p}{5(W/L)_p} I_1 = \frac{\cancel{3}}{5} \times \frac{2}{\cancel{3}} I_{ref}$$

$$\boxed{\therefore I_{copy} = \frac{2}{5} I_{ref}}$$

(b)



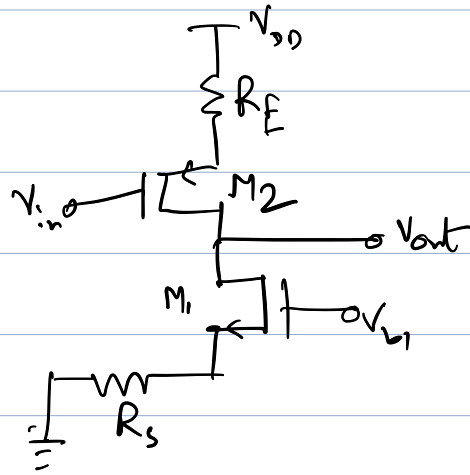
≡



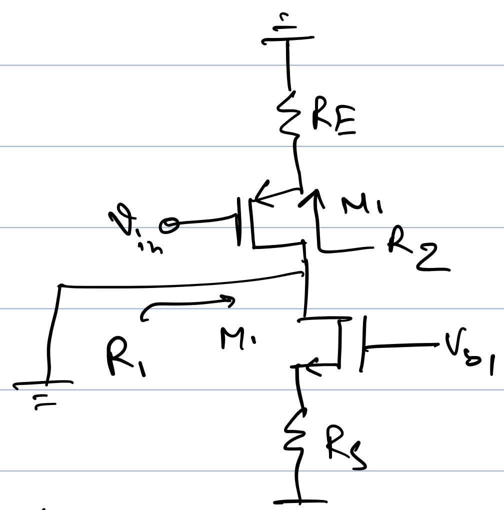
It is a PMOS Common Source Stage degenerated by a diode connected PMOS. The common source stage has a current source load.

$\therefore$ The voltage gain $A_V = -\dfrac{r_{o2}}{1/g_{m1} + 1/g_{m3}}$

(3) (a)



Equivalent circuit



This is a common-source stage with degeneration

$$\therefore G_M = \frac{g_{m2}}{1 + g_{m2} R_E}$$

$$R_1 = (1 + g_{m1} R_S) r_{o1} + R_S$$

$$R_2 = (1 + g_{m2} R_E) r_{o2} + R_E$$

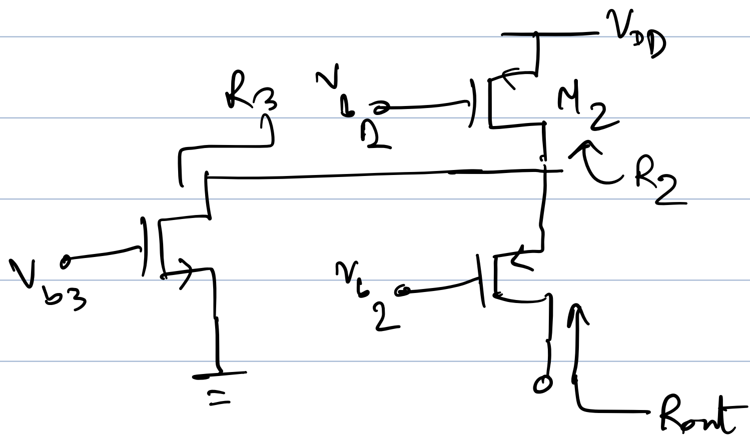
$$\therefore A_v = -G_M (R_1 \| R_2)$$

$$= -\frac{g_{m2}}{1 + g_{m2} R_E} \left[(1 + g_{m1} R_S) r_{o1} + R_S \right] \| \left[(1 + g_{m2} R_E) r_{o2} + R_E \right]$$

(b) Because, due to the side-diffusion of the source and drain areas (L_D). This is because if Ldraw is doubled, then $L_{eff} = L_{drawn} - 2L_D$ is not.

(c) Ans: (iii) Common-drain

(4)



By observation:

$R_2 = r_{o2}$

$R_3 = r_{o3}$

$$\boxed{\therefore R_{out} = g_{m1} r_{o1} (r_{o2} \| r_{o3})}$$