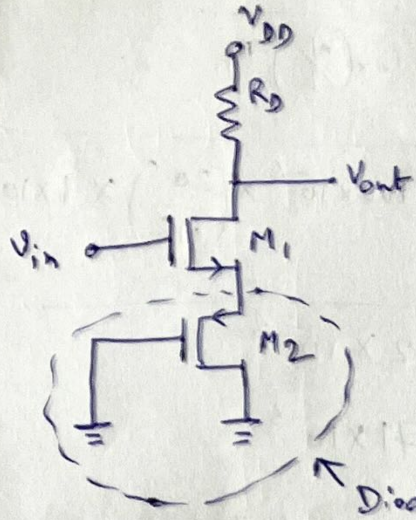
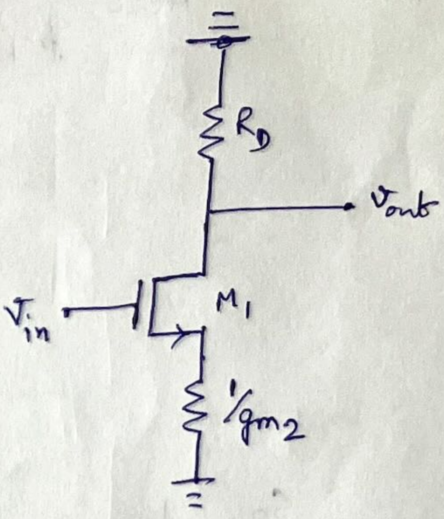
Q.1

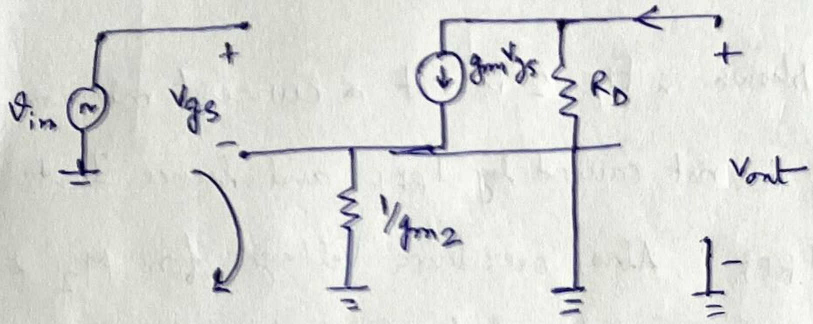


Diode connected PMOS

For $\gamma=0, \lambda=0$ $\Rightarrow$



Small-signal equivalent model:



Using KVL in the input loop

$$v_{in} - v_{gs} - \frac{g_{m1} v_{gs}}{g_{m2}} = 0 \quad \text{or} \quad v_{gs} = \frac{v_{in}}{\left(1+\frac{g_{m1}}{g_{m2}}\right)}$$

$$= \frac{g_{m2} v_{in}}{g_{m1}+g_{m2}}$$

$$v_{out} = -g_{m1} v_{gs} R_D$$

$$= -g_{m1} R_D \frac{(g_{m2} v_{in})}{(g_{m1}+g_{m2})}$$

$$\text{or } A_v = -\frac{g_{m1} g_{m2} R_D}{g_{m1}+g_{m2}}$$

Or, You can directly use the formula of gain for common-source stage with degenerated load.

$$A_v = -\frac{R_D}{1/g_{m1} + 1/g_{m2}}$$

Here, $g_{m1} = g_{m2} = \sqrt{2 \mu C_{ox} \left(\frac{W}{L}\right) I_D}$

$$= \sqrt{2 \times 100 \times 10^{-6} \times \left(\frac{20}{.18}\right) \times 1 \times 10^{-3}}$$

$$= \sqrt{22.2 \times 10^{-6}}$$

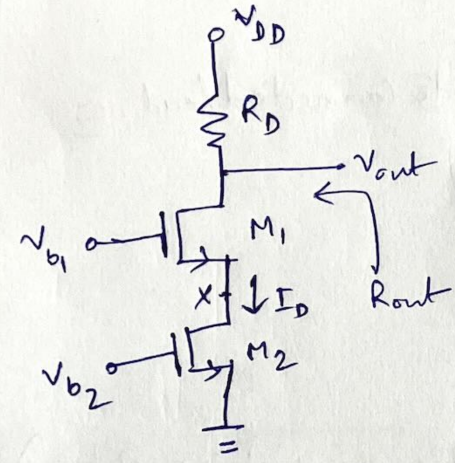
$$= 4.71 \times 10^{-3}$$

So, $A_v = - \dfrac{\cancel{500}^{250} \times 4.71 \times 10^{-3} \times \cancel{4.71 \times 10^{-3}}}{\cancel{2} \times \cancel{(4.71 \times 10^{-3})}}$

$$= -1.178$$

(b) No, the circuit shown in Fig. 2 is not a current mirror circuit. Because, here V_b is not caused by I_{REF}, and hence I_{out} doesn't track I_{REF}. Also, overdrive voltage for M_2 is function of V_b which is external ~~power~~ supply voltage. Therefore I_{out} is not independent of external supply voltage.

1) (a)



$$g_{m1} = \sqrt{2\mu_n C_{ox}\left(\frac{W}{L}\right)_1 \times I_D}$$

$$= \sqrt{2 \times 100 \times 10^{-6}\left(\frac{20}{0.18}\right) \times 1 \times 10^{-3}}$$

$$= 4.71 \times 10^{-3}$$

$$r_{o1} = \frac{1}{\lambda_1 I_D} = r_{o2}$$

$$= \frac{1}{0.1 \times 10^{-3}}$$

$$= 10^4$$

for both M_1 and M_2 to be in saturation

$V_{DS1} \geq$ overdrive voltage of M_1

$V_{DS2} \geq$ overdrive " " M_2

or, $V_{DS1} \geq V_{GS1} - V_{th1}$

$\geq V_{b1} - V_X - V_{th1}$

or, $V_{D1} \geq V_{b1} - V_{th1}$

Therefore, the highest allowable value of V_{b1} should be, $V_{b1} = V_{D1} + V_{th1}$

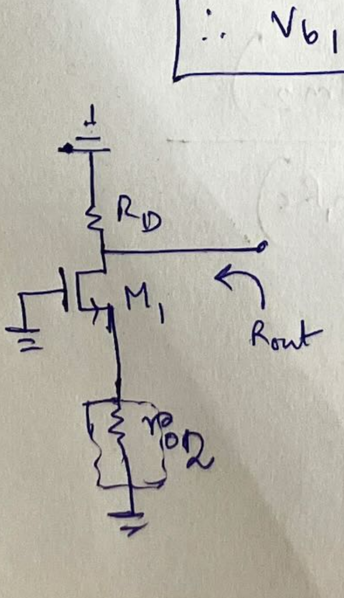
$V_{D1} = V_{DD} - I_D R_D$

$= 1.8 - (1mA \times 500\Omega)$

$= 1.3V$

$$\boxed{\therefore V_{b1} = (1.3 + 0.4)V = 1.7V}$$

(b)



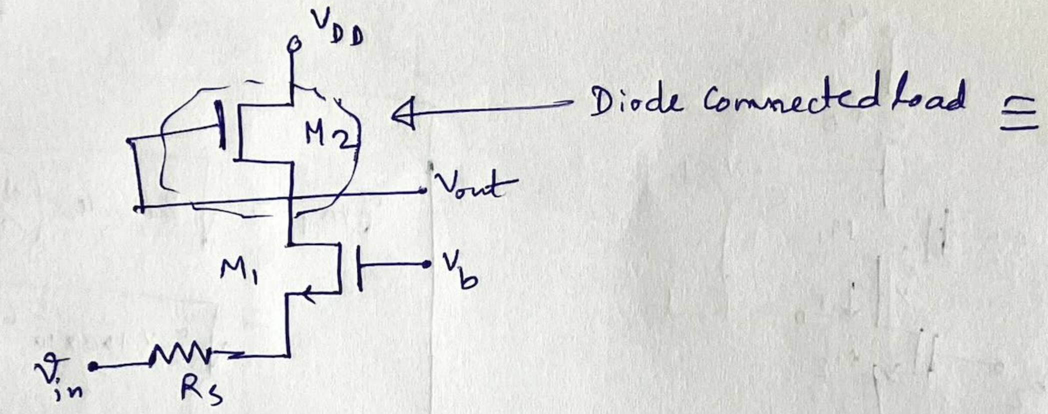
$$R_{out} = \{(1 + g_{m1} r_{o1}) r_{o2} + r_{o1}\} \,||\, R_D$$

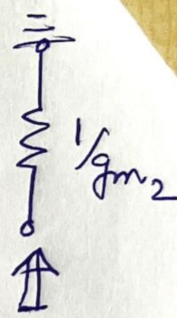
$$\simeq g_{m1} r_{o1} r_{o2} \,||\, R_D$$

$$\simeq R_D$$

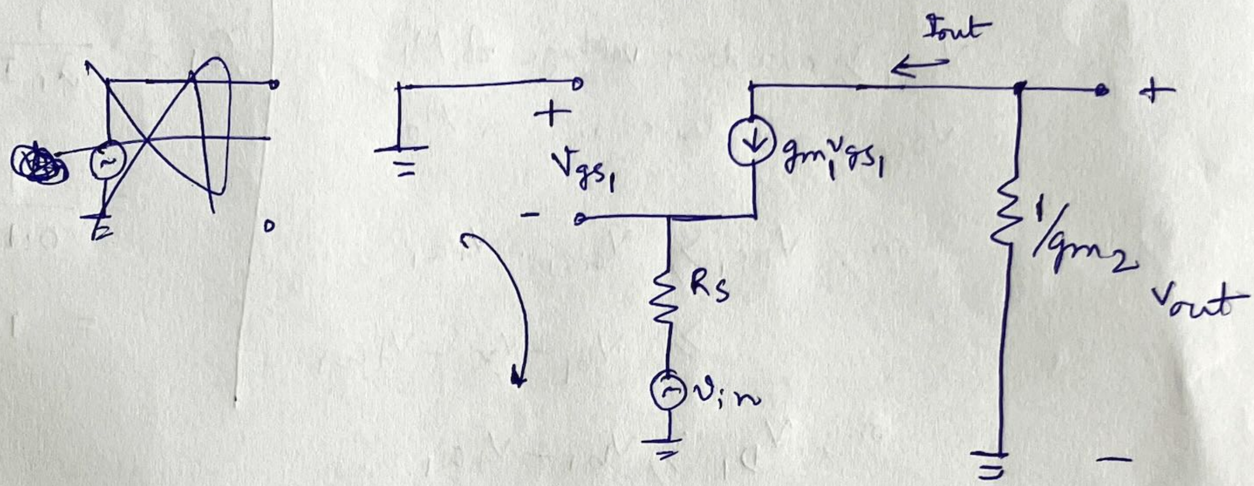
$$= 500\Omega$$

Q.3





(a) Small signal equivalent Model (Assuming $\lambda = 0, \gamma = 0$)



(b) Using KVL in the i/p loop

$$-v_{gs_1} - R_S g_{m_1} v_{gs_1} - v_{in} = 0$$

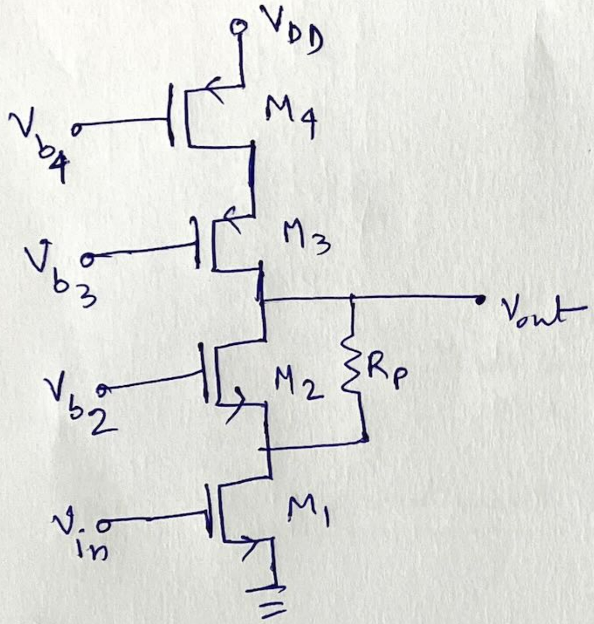
or $$v_{in} = -v_{gs_1}(R_S g_{m_1} + 1)$$

Whereas,

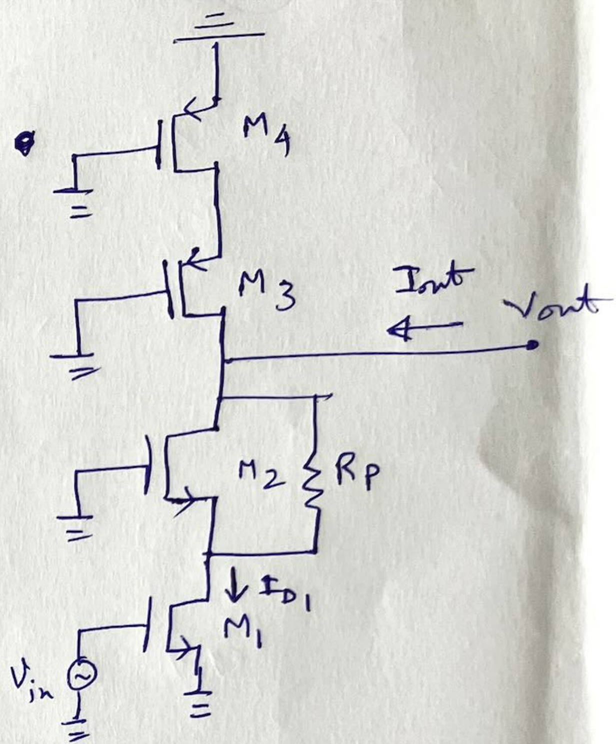
$$V_{out} = -g_{m_1} v_{gs_1} \times \left(1/g_{m_2}\right)$$

$$\therefore A_v = \frac{V_{out}}{v_{in}} = \frac{+\left(g_{m_1}/g_{m_2}\right)}{\left(1 + g_{m_1} R_S\right)}$$

1) (a) This is a Cascode amplifier



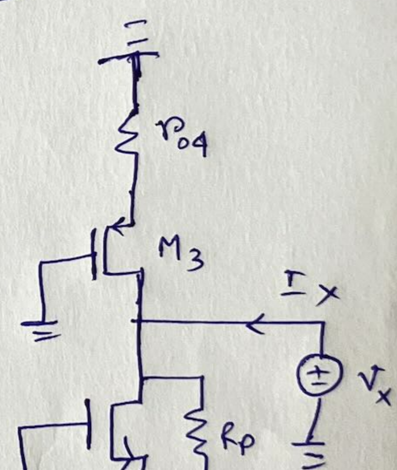
$\equiv$

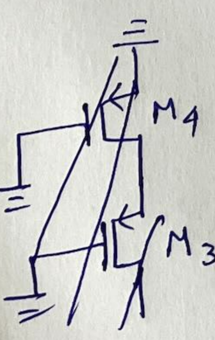


$I_{out} = g_{m1} v_{in}$

$\therefore \; G_m = \dfrac{I_{out}}{v_{in}} = g_{m1}$

R_{out} :





Assuming $g_m r_o >> 1$,

$$\therefore \; R_{out} = \left\{ g_{m2} (r_{o2} \| R_P) \, r_{o1} \right\} \| \left\{ g_{m3} \, r_{o4} \, r_{o3} \right\}$$

$$\therefore \; A_v = -G_m R_{out} = -g_{m1} \left[g_{m3} \, r_{o3} \, r_{o4} \, \| \, g_{m2} (r_{o2} \| R_P) \, r_{o1} \right]$$

(b) Ans: (ii)

(c) Ans: (iv)