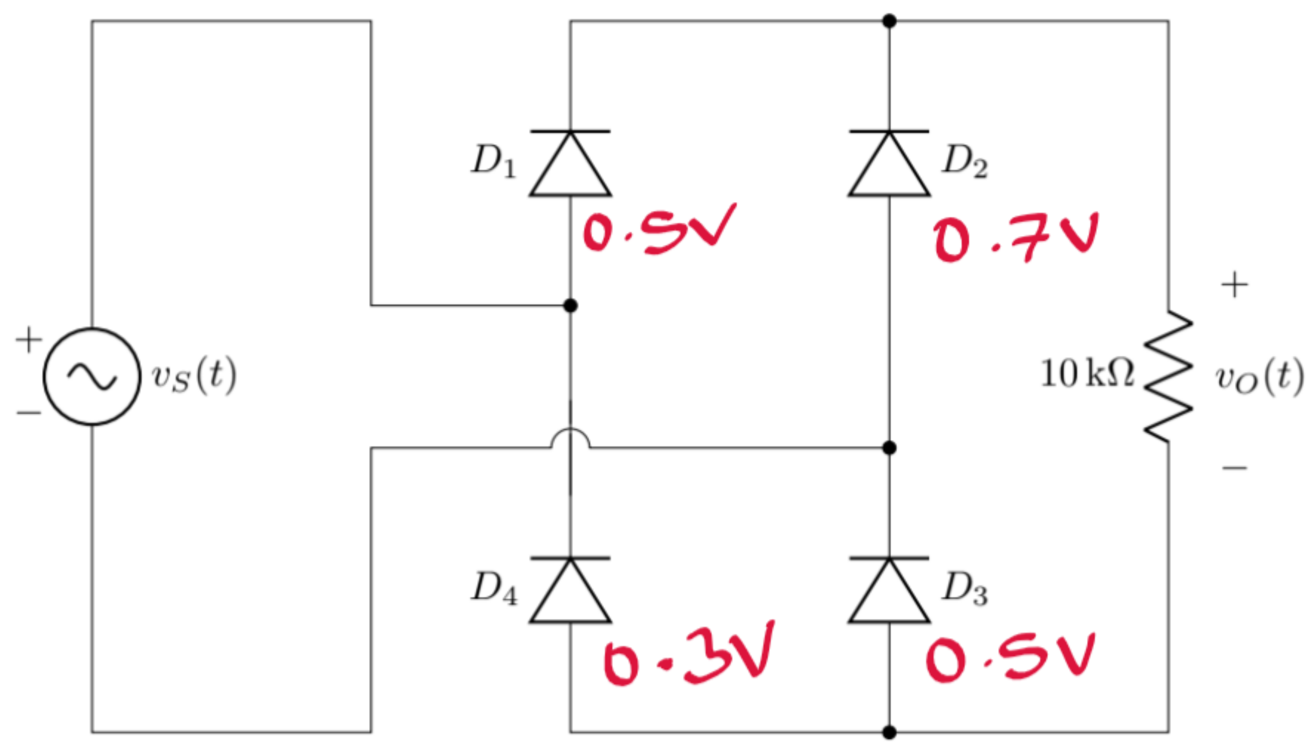
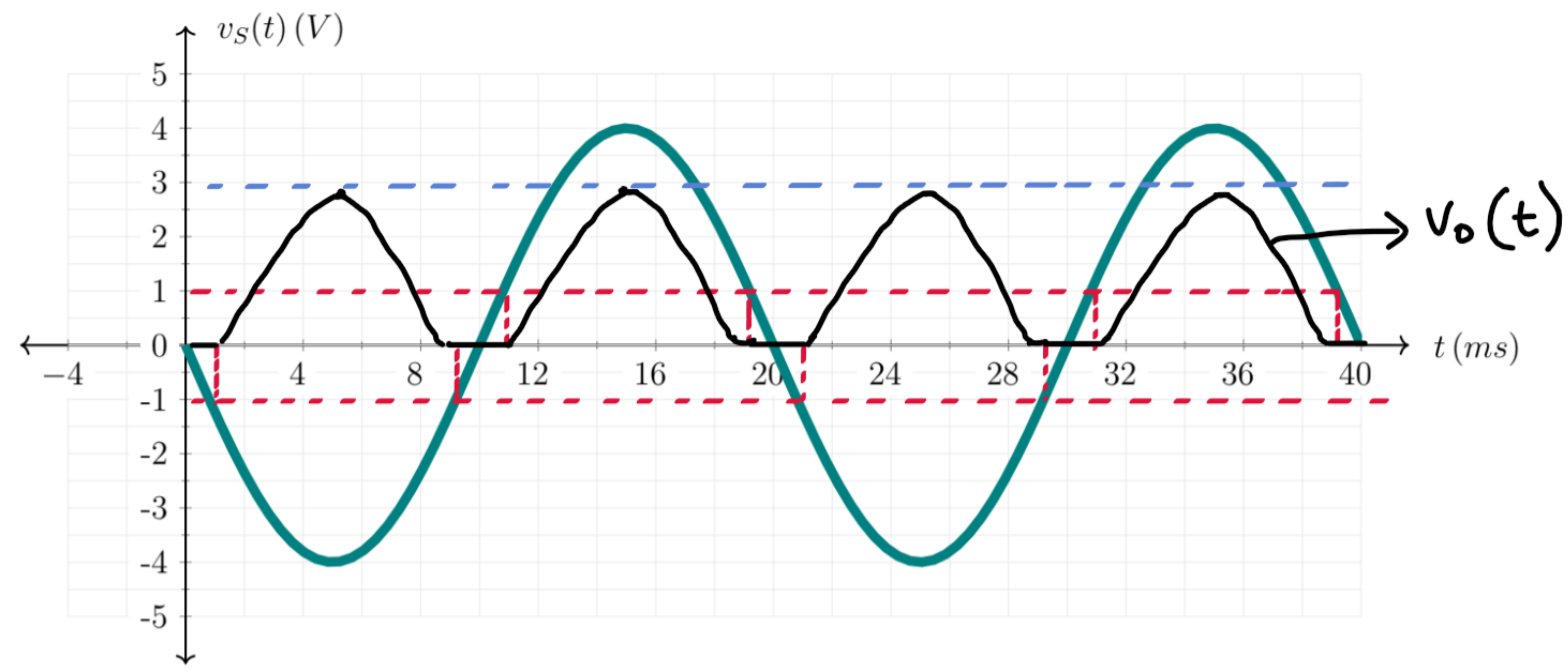
CSE251 Final (Summer 25) - set A

1) a)





In +ve cycle, D_1 and D_3 are ON

$\therefore V_p = V_m - V_{D_1} - V_{D_3} = 4 - 0.5 - 0.5 = 3\,V$

In -ve cycle, D_2 and D_4 are ON

$\therefore V_p = V_m - V_{D_2} - V_{D_4} = 4 - 0.7 - 0.3 = 3\,V$

b) $V_r = 10\%$ of $V_p = 0.1 \times 3 = 0.3\,V$

$V_r = V_p / 2fRC$

$\Rightarrow C = V_p / 2fRV_r$

$= 3 / 2\times 50 \times 10 \times 10^3 \times 0.3$

$= 1 \times 10^{-5}\,F$ or $10\,\mu F$

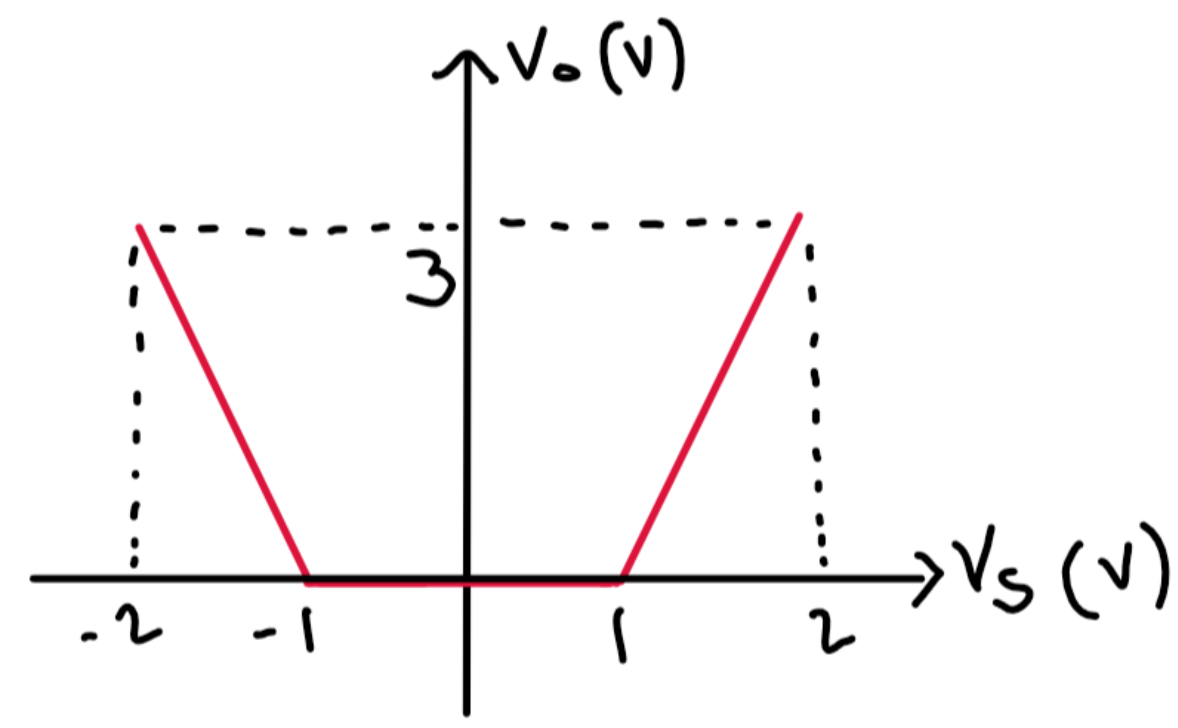
$V_p = 3$

$f = 1/T = 1/20\,ms = 50\,Hz$

$R = 10\,k\Omega$

c) $V_{dc} = V_p - \dfrac{V_r}{2} = 3 - \dfrac{0.3}{2} = 2.85\,V$

d)

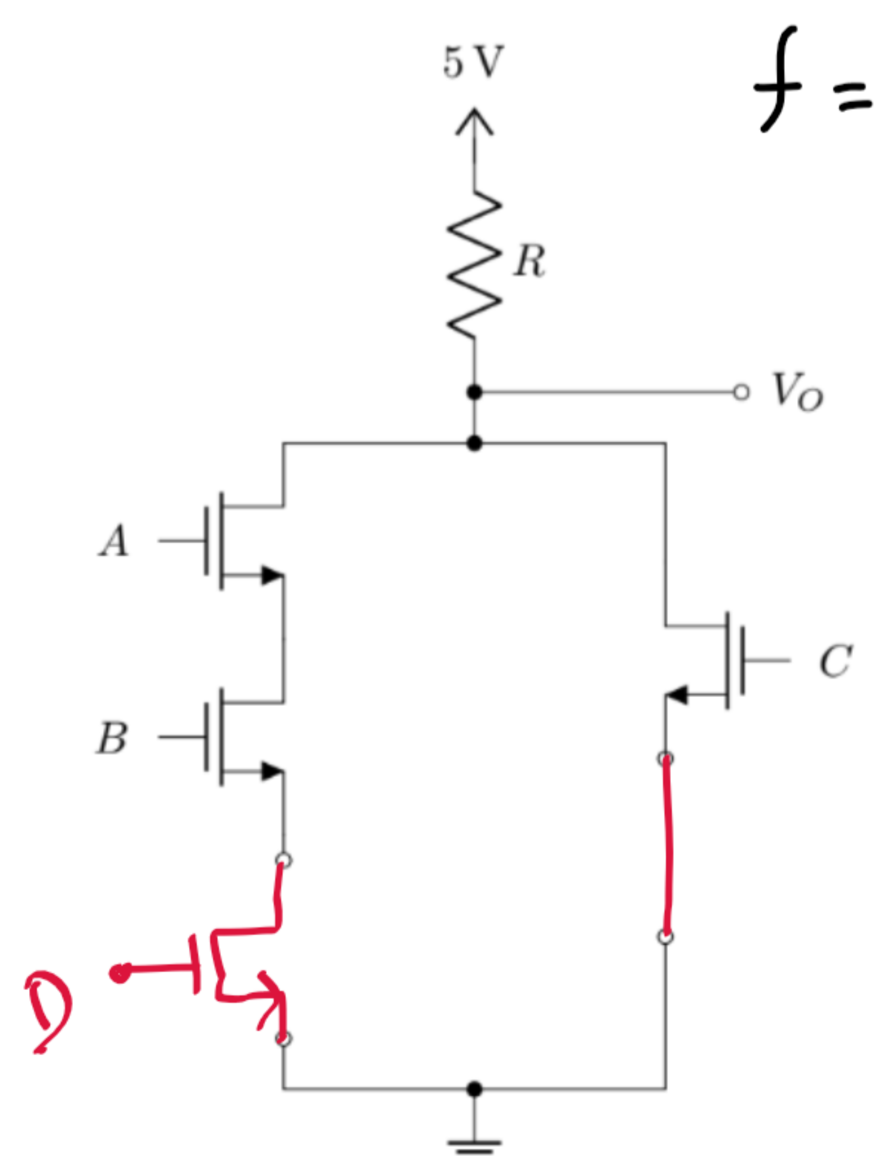


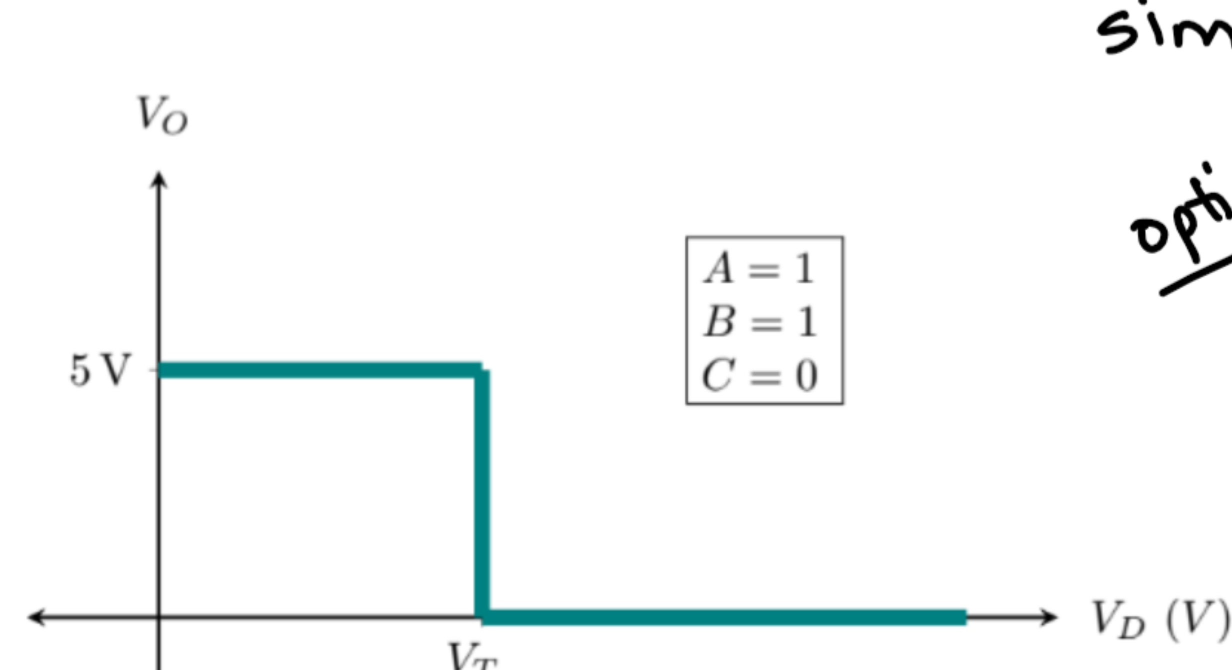
2) a) MOSFET → triode and cutoff

BJT → saturation and cutoff

b) In cutoff. $V_G = V_S$, so $V_{GS} = 0 < V_{T_n}$

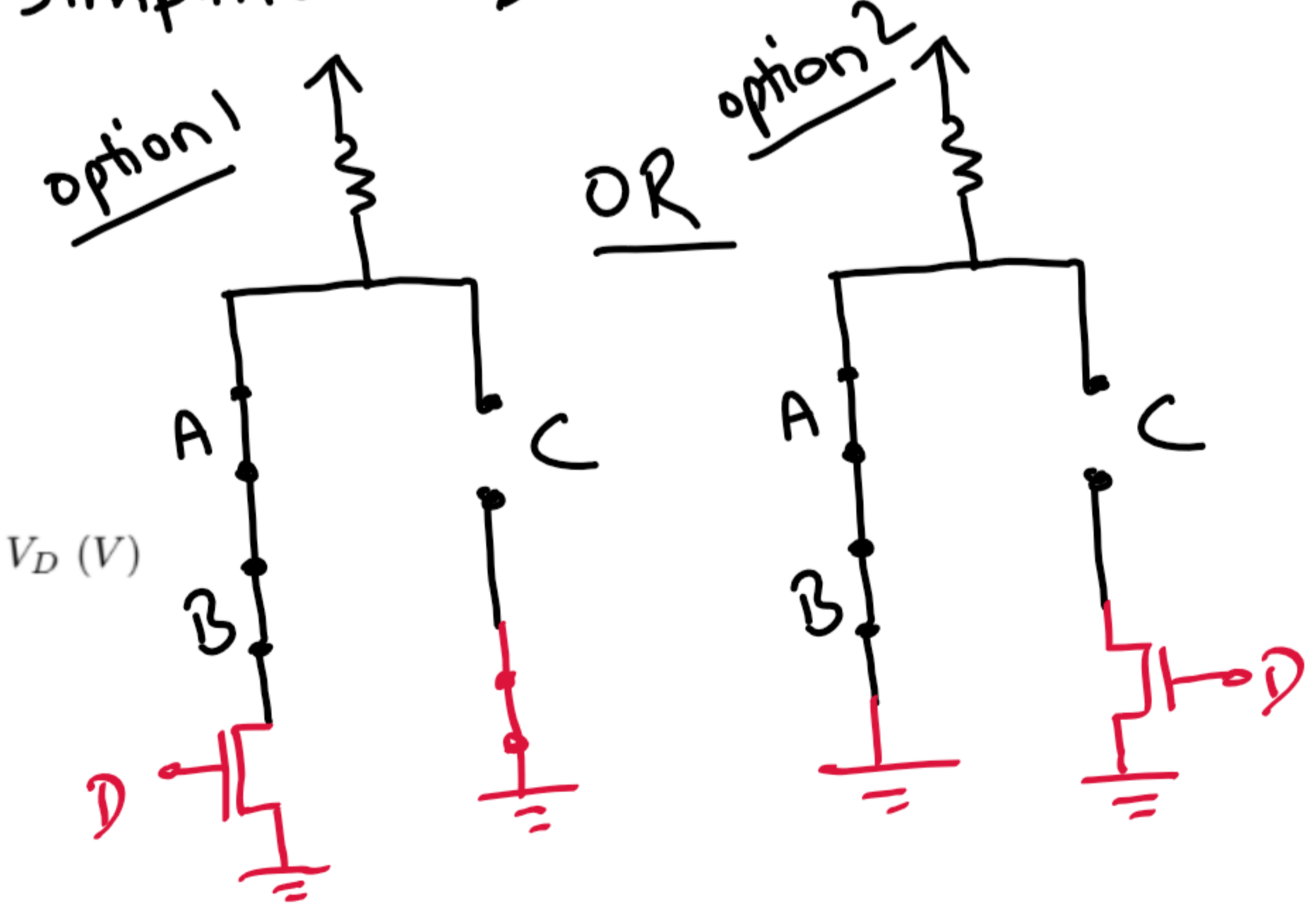
c) $f = \overline{ABD + C}$



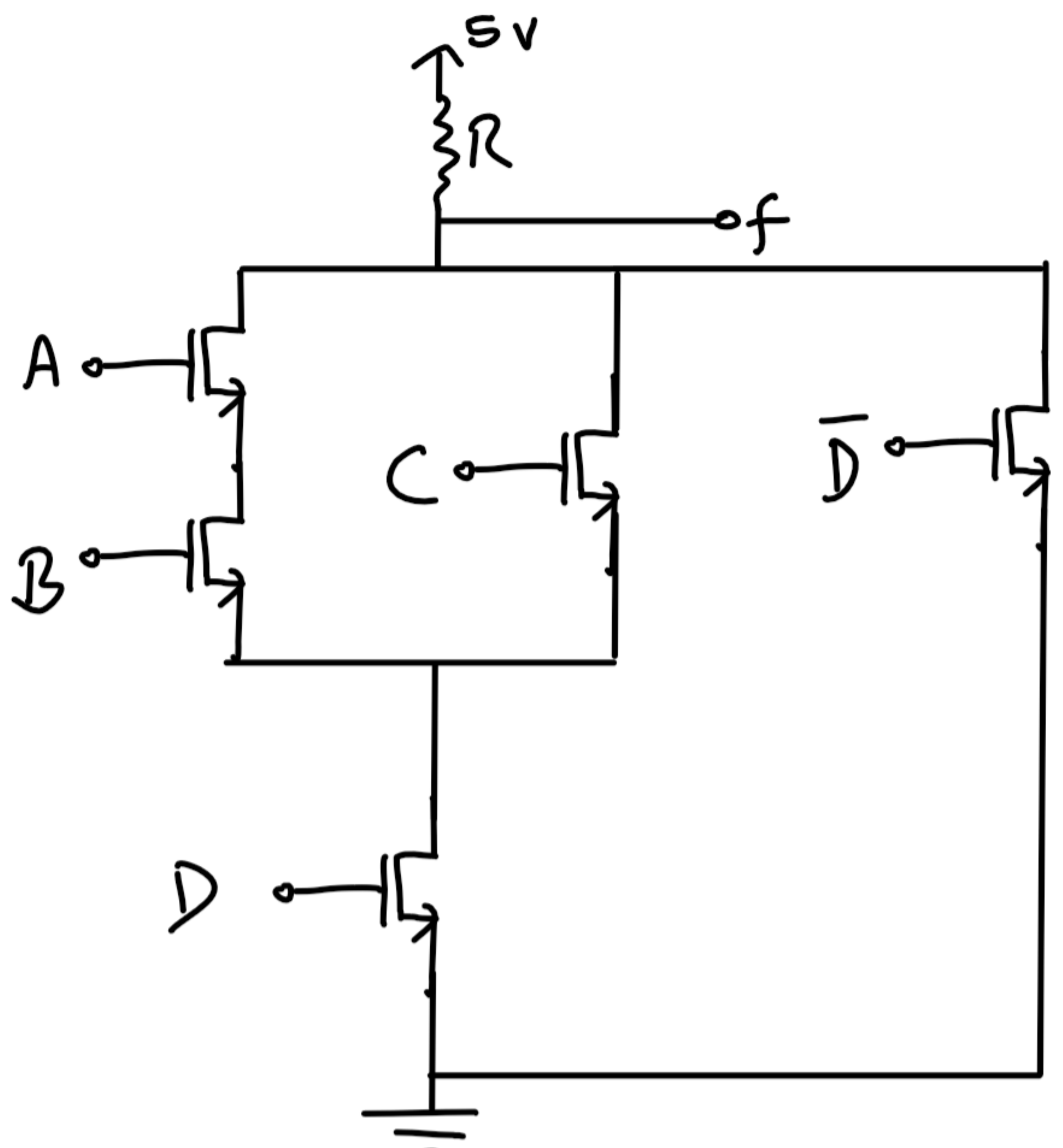


matches with option 1.

Using the VTC, the circuit simplifies to:

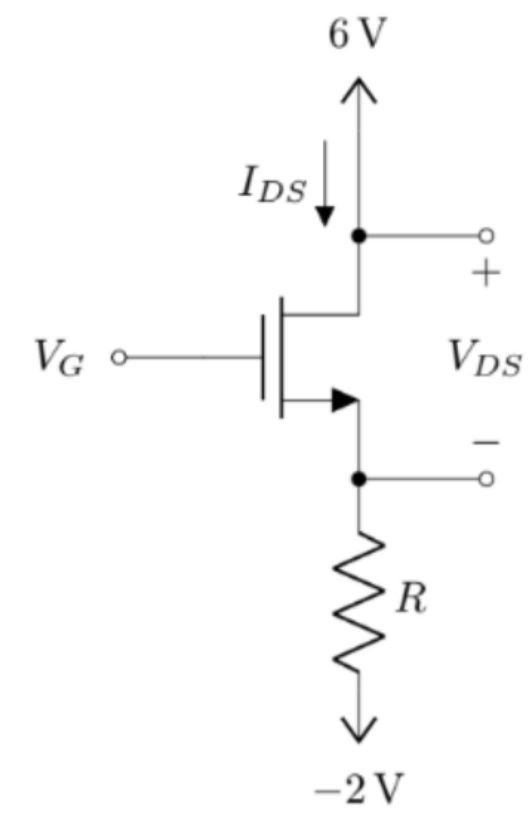


3) a) $f = \overline{(AB + C)D + \overline{D}}$



* $\overline{D}$ can be shown coming from another sub-circuit (any valid working is fine)

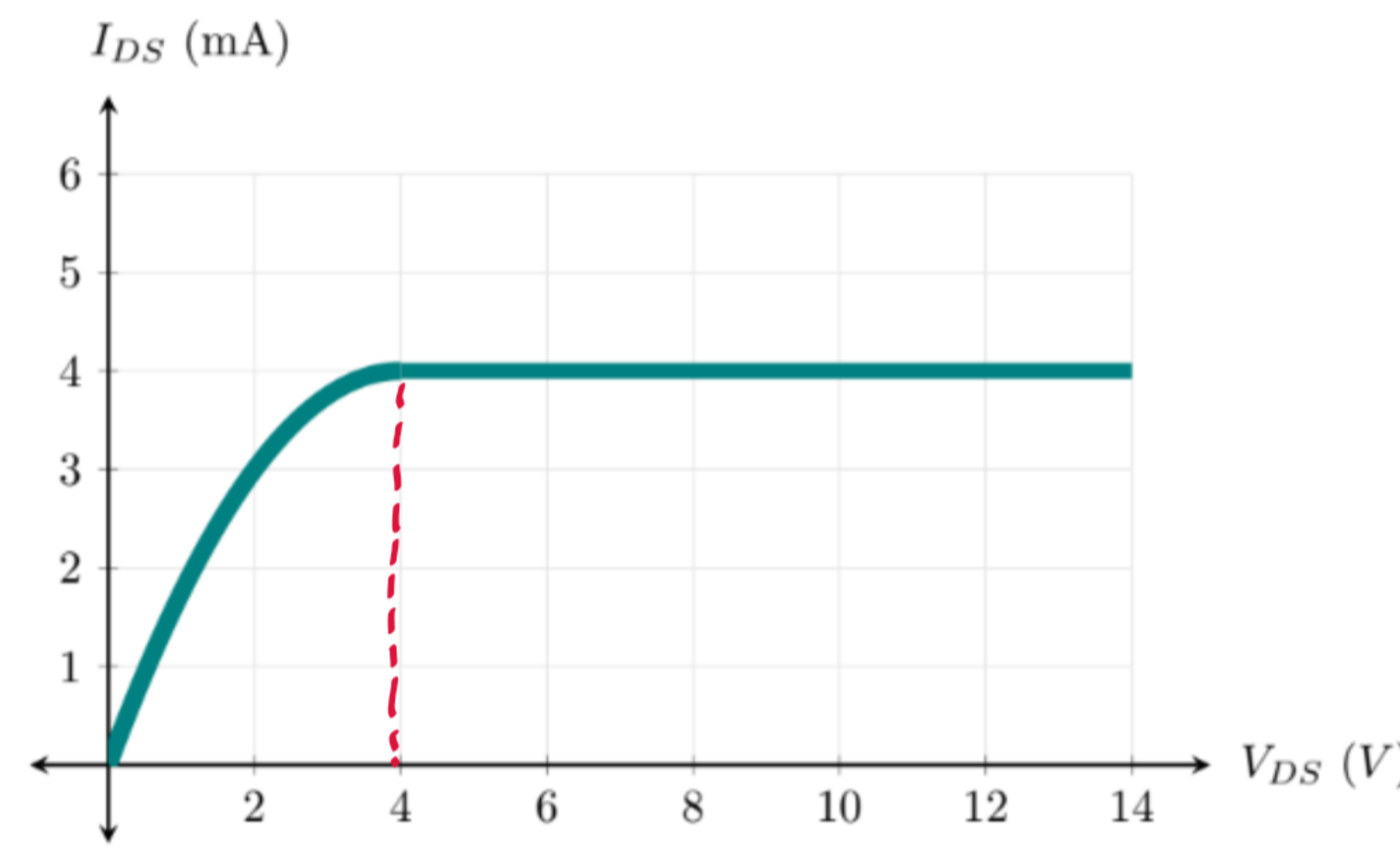
b) i)



$V_D = 6$ V

$V_S = ?$

$V_G = ?$



From graph, $V_{ov} = 4$ V at $I_{DS} = 4$ mA

At edge of saturation,

Equating these two removes the need to calculate k, making this step optional.

$$I_{DS} = \frac{1}{2} k V_{ov}^2 \longrightarrow k = \frac{1}{2} \text{ mA/V}^2$$

$$I_{DS} = k\left(V_{ov} - \frac{1}{2}V_{DS}\right)V_{DS}$$

$$\Rightarrow \quad 4 = \frac{1}{2}\left(4 - \frac{1}{2}V_{DS}\right)V_{DS}$$

$$\therefore V_{DS} = 4 \text{ V}$$

now,

$$V_{DS} = V_D - V_S$$

$$\therefore V_S = 2 \text{ V}$$

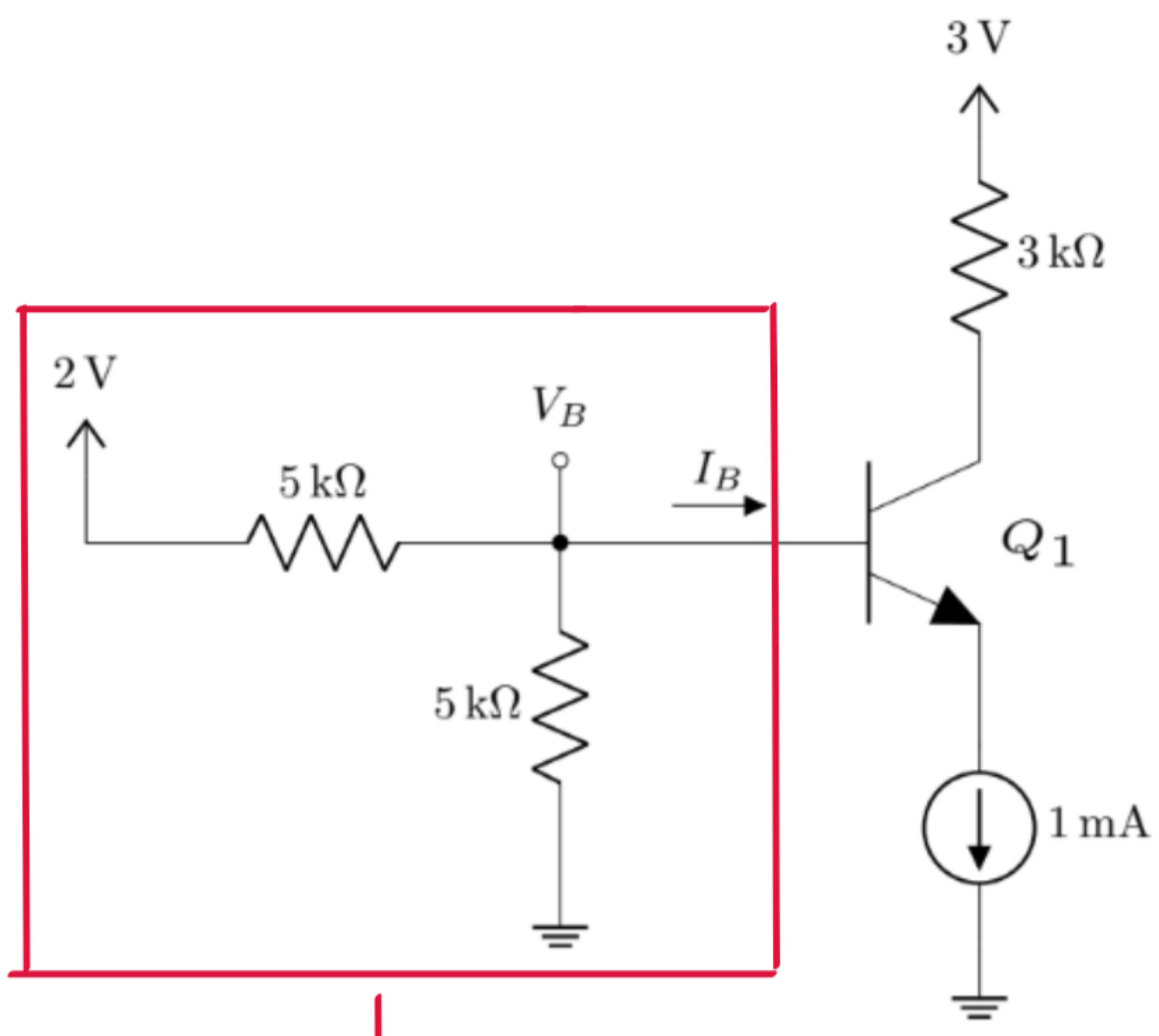
From $V_{OV} = V_G - V_S - V_T$

$$\therefore V_G = 7 \text{ V}$$

ii) $I_{DS} = 4 = \dfrac{V_S - (-2)}{R}$

$$\therefore R = 1 \text{ k}\Omega$$

4)



NPN BJT Parameters:

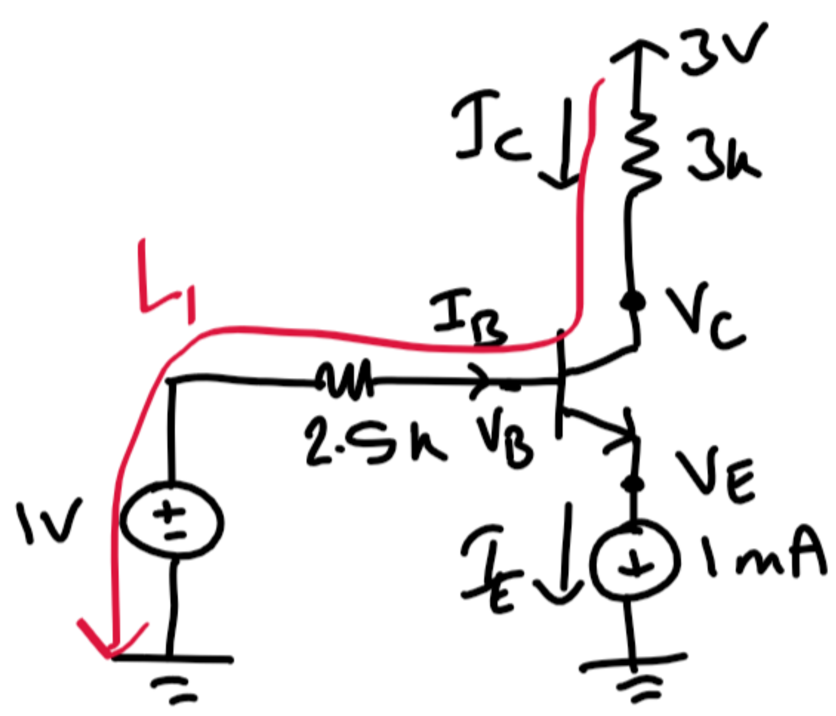
For the transistor Q_1:

Current gain: $\beta = 100$

Base-emitter voltage in saturation: $V_{BE(sat)} = 0.8\,\text{V}$

Collector-emitter voltage in saturation: $V_{CE(sat)} = 0.2\,\text{V}$

Thevenin's equivalent



$\underline{L_1}$: $3 = 3I_C + V_{CB} - 2.5I_B + 1$

$\Rightarrow 3 - 1 = 3I_C - 2.5I_B + \underbrace{V_{CE}}_{0.2} - \underbrace{V_{BE}}_{0.8}$ (Assuming saturation)

$\Rightarrow 3I_C - 2.5I_B = 2.6$ — (i)

$\underline{KCL}$: $I_E = I_C + I_B$

$\Rightarrow I_C + I_B = 1$ — (ii)

solving, $I_C = 51/55 = 0.927\,\text{mA}$

$I_B = 4/55 = 0.073\,\text{mA}$

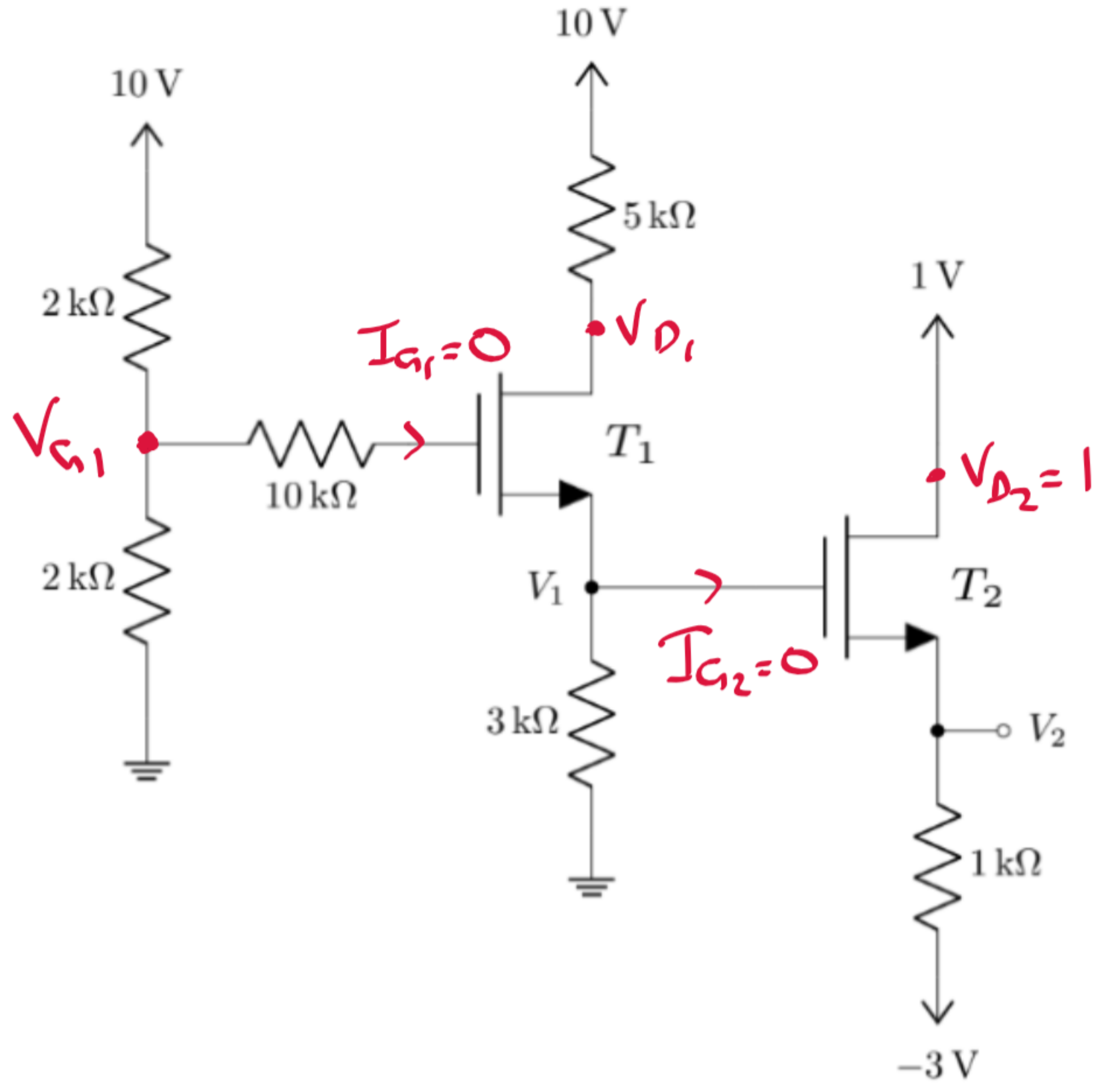
$I_C/I_B = 12.75 < \beta_{active}$ $\therefore$ Q_1 is in saturation

$V_B = -2.5I_B + 1 = 0.818\,\text{V}$

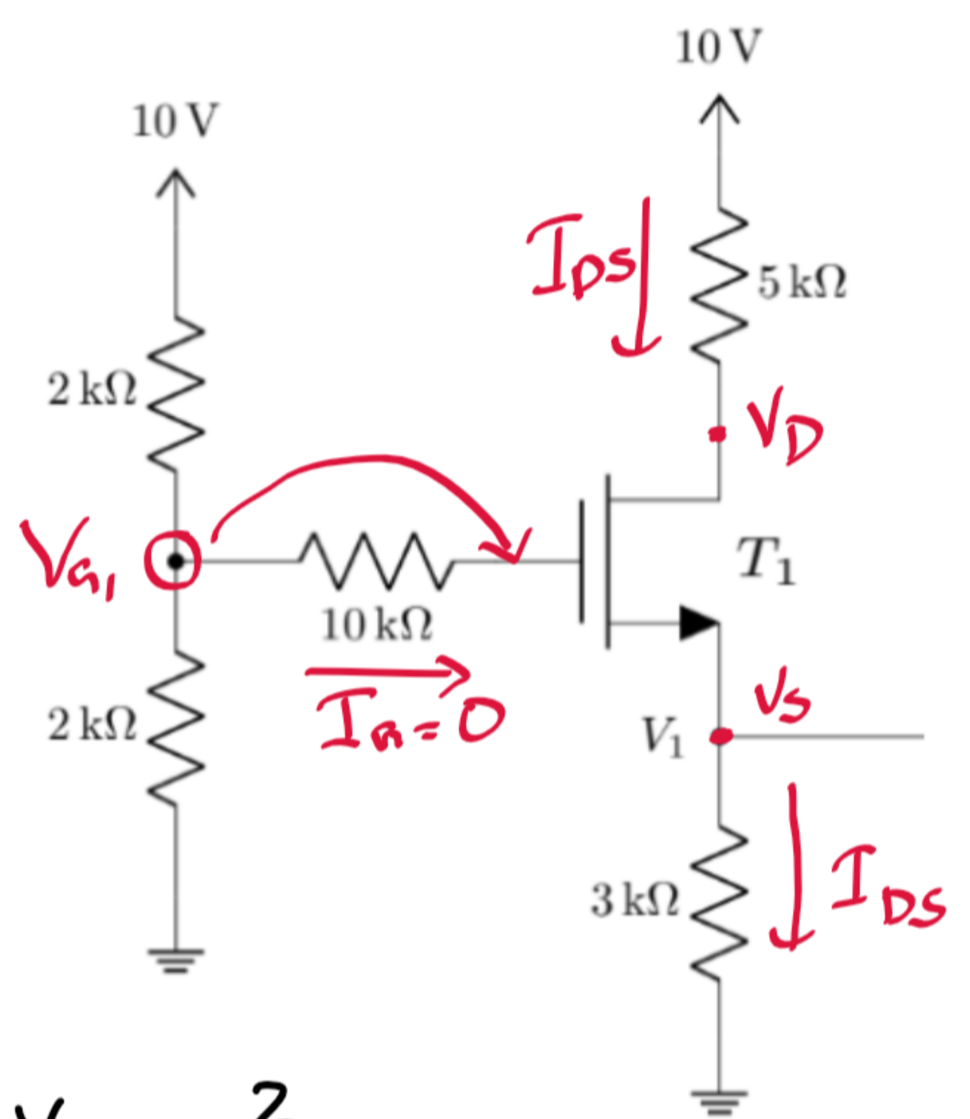
$V_C = -3I_C + 3 = 0.218\,\text{V}$

$V_E = V_C - V_{CE} = 0.018\,\text{V}$

5)



a)



$$V_{G_1} = \frac{2}{2+2} \times 10$$

$$= 5V$$

Given that T_1 is in saturation,

$$I_{DS} = \frac{1}{2} k V_{ov}^2$$

$$= \frac{1}{2} \times 2 \times (V_G - V_S - V_T)^2$$

$$= (4 - V_s)^2$$

$$= V_s^2 - 8V_s + 16 \quad \text{— (i)}$$

$$I_{DS} = \frac{V_s - 0}{3} \quad \text{— (ii)} \qquad I_{DS} = \frac{10 - V_{D_1}}{5} \quad \text{— (iii)}$$

Equating (i) and (ii),

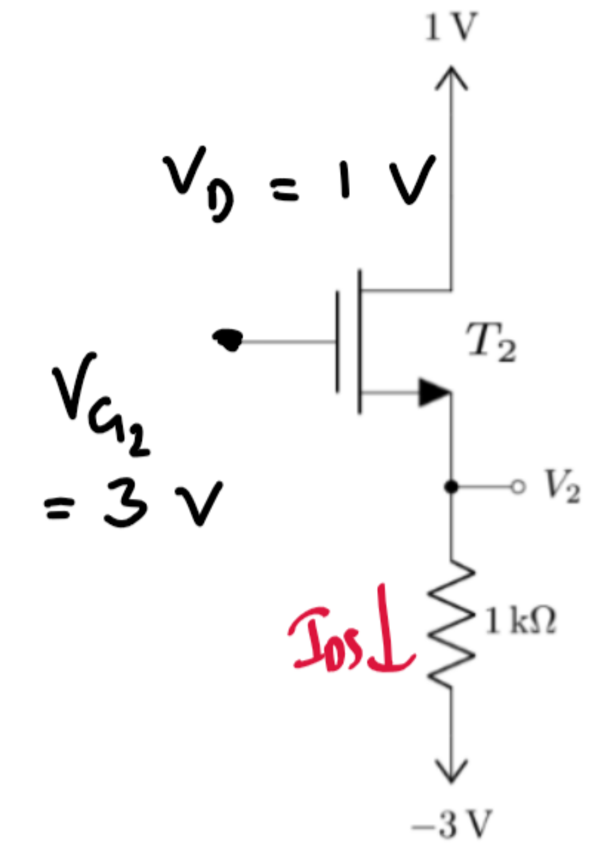
$$V_s^2 - \frac{25}{3} V_s + 16 = 0$$

$$V_s = \cancel{16/3} \quad \text{or} \quad 3$$

as $V_{GS} < V_T$

From (ii) and (iii), $V_{D_1} = 5V$ and $V_1 = V_S = 3V$

b)



Assume triode,

$$I_{DS} = k\left(V_{ov} - \frac{1}{2} V_{DS}\right) V_{DS}$$

$$= 2\left(3 - V_S - 1 - \frac{1}{2} \times 1 + \frac{1}{2} V_S\right)(1 - V_S)$$

$$= 2\left(\frac{3}{2} - \frac{1}{2} V_S\right)(1 - V_S)$$

$$= (3 - V_S)(1 - V_S)$$

$$= V_S^2 - 4V_S + 3 \quad \text{— (i)}$$

$$I_{DS} = \frac{V_S - (-3)}{1} \quad \text{— (ii)}$$

Equating (i) and (ii),

$$V_S^2 - 5V_S = 0$$

$$\Rightarrow V_S = \cancel{5\,V} \quad \text{or} \quad 0\,V$$

$V_{GS} < V_T$

$\therefore V_S = 0$ V

$V_{GS} = 3$ V

$V_{ov} = 2$ V

$V_{DS} = 1$ V

$V_{DS} < V_{ov}$ $\therefore T_2$ is operating in triode mode.

$\therefore V_2 = V_S = 0$ V