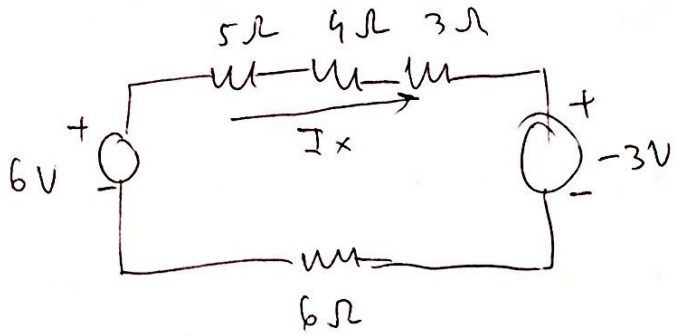
① a)

$U_{AB} = 4 - 16 + 18 = 6V$

$R_{AB} = 5\Omega$

d) $U_{CD} = 6V - 9V = -3V$

$R_{CD} = 3\Omega$

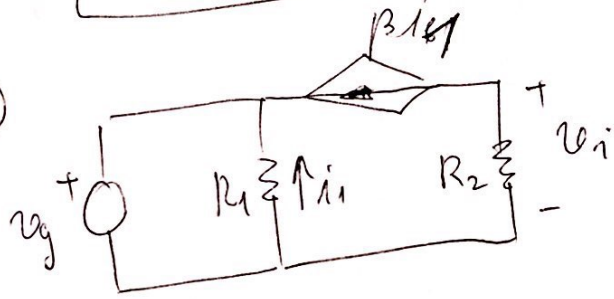


$-3V + I_x(5+3+4+6) * 6 = 0$

$I_x = \frac{9}{18} = \frac{1}{2} A$

$P_{4\Omega} = 1W$

②



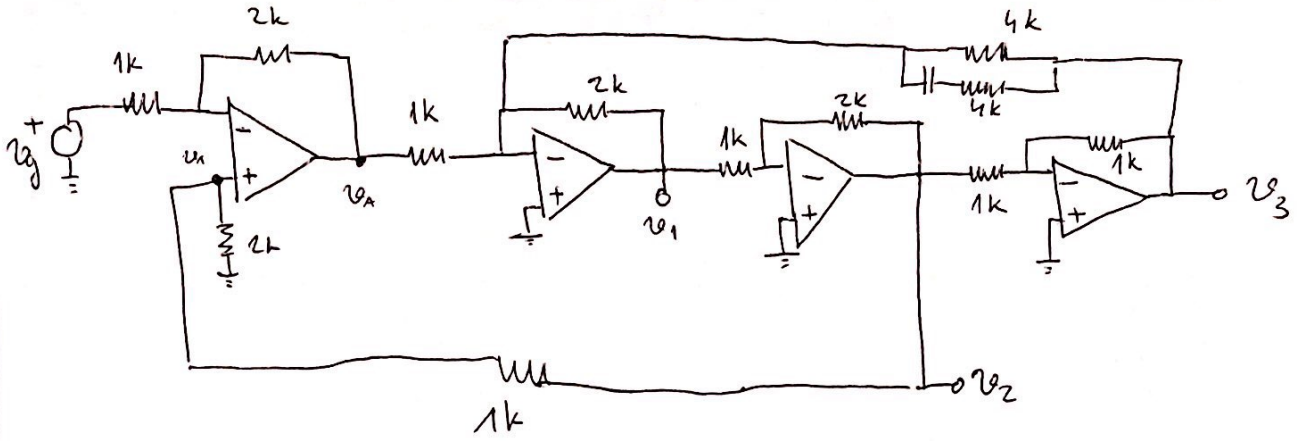
$v_i = -\beta i_1 \cdot R_2$

$v_i = \beta \cdot \frac{R_2}{R_1} v_g$

~~$i_g = -i_1(1+\beta)$~~

$i_1 = -\frac{v_g}{R_1}$

$\frac{v_i}{v_g} = \beta \cdot \frac{R_2}{R_1}$



AC: $v_x = \frac{2}{3} v_2$

$\frac{v_1}{1} = \frac{v_A - v_2}{2}$

$v_2 = -2v_1$

$v_3 = -v_2$

$= 2v_1$

$\frac{v_g - \frac{2}{3}v_2}{1} = \frac{\frac{2}{3}v_2 - v_A}{2}$

$2v_g - \frac{4}{3}v_2 = \frac{2}{3}v_2 - v_A$

$v_A = 2v_2 - 2v_g$

$v_A = 2(v_2 - v_g)$

$v_2 = -2v_1 \mid \cdot 4$

$4v_2 = -8v_1$

$v_1 + v_3 = -2v_A$

$3v_1 = -4v_2 - 4v_g$

$-5v_1 = 4v_g$

$v_1 = -\frac{4}{5}v_g$

$v_1 = -0{,}8 \sin \omega t$

$v_2 = 1{,}6 \sin \omega t$

$v_3 = -1{,}6 \sin \omega t$

* $\frac{v_A}{1} = \frac{-v_1}{2} - \frac{v_3}{2}$

$v_1 + v_3 = -2v_A$

$3v_1 = -4v_2 + 4v_g$

$-5v_1 = 4v_g$

$v_1 = -\frac{4}{5}v_g$

$11v_1 = 4v_g$

$v_1 = \frac{4}{11}v_g$

$v_x = \frac{2}{3}v_2$

$\frac{v_A}{1} = -\frac{v_1}{2} - \frac{v_3}{4} \mid \cdot 4$

$4v_A = -2v_1 - v_3$

$2v_1 + v_3 = -4v_A$

$2v_3 = -4v_A$

$v_3 = -2v_A = -4v_2 + 4v_g$

$v_3 + 4v_2 = 4v_g$

$3v_2 = 4v_g$

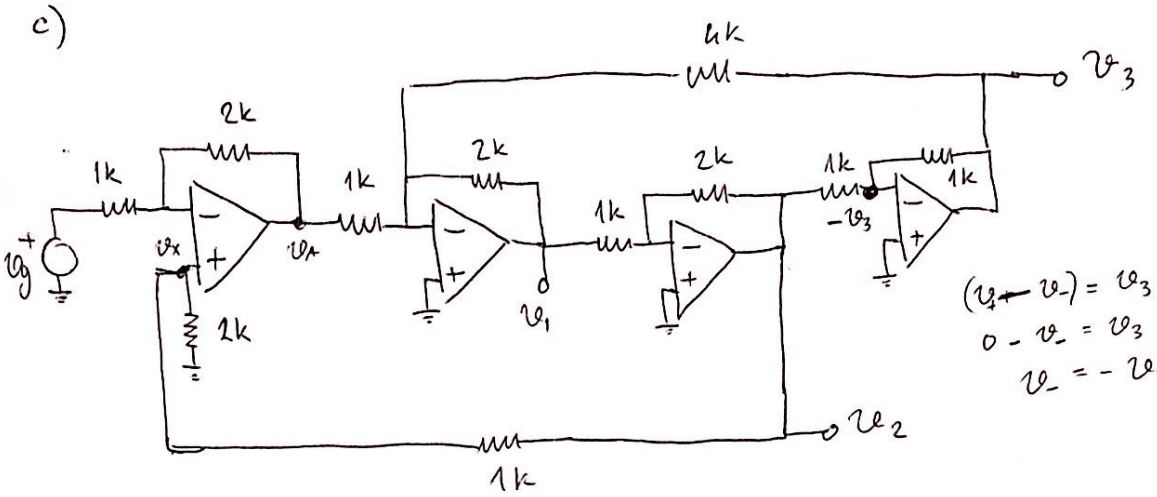
$v_2 = \frac{4}{3}v_g$

$v_2 = \frac{4}{3}V$

$v_3 = -\frac{4}{3}V$

$v_1 = -\frac{2}{3}V$

c)



$(v_+ - v_-) = v_3$

$0 - v_- = v_3$

$v_- = -v_3$

$v_x = \frac{2}{3} v_2$

$\frac{v_g - \frac{2}{3} v_2}{1} = \frac{\frac{2}{3} v_2 - v_A}{2}$

$2v_g - \frac{4}{3} v_2 = \frac{2}{3} v_2 - v_A$

$\boxed{v_A = 2(v_2 - v_g)}$

$\frac{v_1}{1} = -\frac{v_2}{2}$

$\boxed{v_2 = -2v_1}$

$v_2 + v_3 = -2v_3$

$\boxed{v_2 = -3v_3}$

$\frac{v_A}{1} = \frac{-v_1}{2} - \frac{v_3}{4} \quad / \cdot 4$

$-4v_A = 2v_1 + v_3$

$-8v_2 + 8v_g = 2v_1 + v_3$

$8v_g = 8v_2 + 2v_1 + v_3 = -24v_3 + 3v_3 + v_3$

$v_3 = -\frac{8}{20} v_g = -\frac{4}{10} v_g = \boxed{-\frac{2}{5} v_g = v_3}$

$\boxed{v_2 = \frac{6}{5} v_g}$

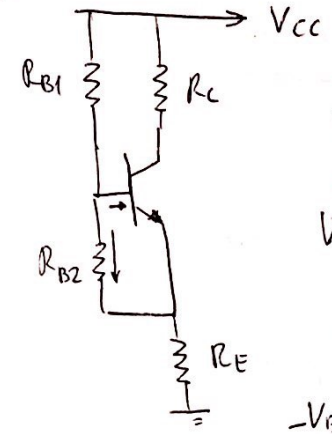
$\boxed{v_1 = -\frac{3}{5} v_g}$

$v_3 = -0{,}4$

$v_2 = 1{,}2$

$v_1 = -0{,}6$

DC:



$$V_{cc} - (i_B + i_x) R_{B1} - ((1+\beta) i_B + i_x) R_E = 0$$

$$V_{cc} - (i_B + i_x) R_{B1} - V_{BE} - ((1+\beta) i_B + i_x) R_E = 0$$

$$i_x = \frac{V_{BE}}{R_{B2}} = 700\,\mu A$$

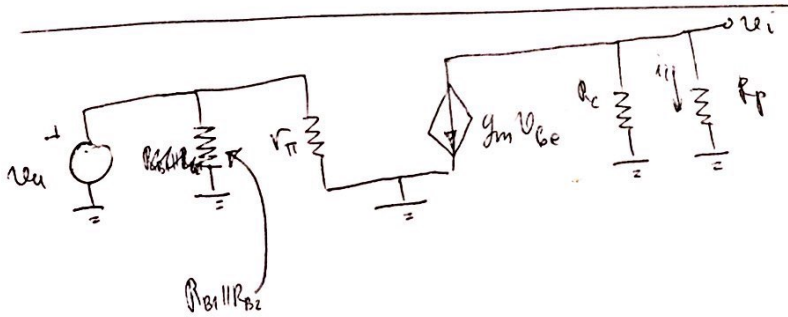
$$V_{cc} - (i_B + i_x) R_{B1} \overset{-V_{BE}}{-} ((1+\beta) i_B + i_x) R_E = 0$$

$$V_{cc} - i_B R_{B1} - i_x R_{B1} \overset{-V_{BE}}{-} (1+\beta) i_B R_E - i_x R_E = 0$$

$$\frac{V_{cc} - V_{BE} - i_x (R_{B1} + R_E)}{R_{B1} + (1+\beta) R_E} = i_B = 2{,}62 \cdot 10^{-5} A = 26{,}2\,\mu A$$

$$V_C = V_{cc} - R_C \cdot \beta \cdot i_B = \underline{7{,}38 V} \qquad \underline{I_C = 1{,}31 mA}$$

$$g_m = 52{,}4 mS \qquad r_\pi = 954{,}2 \Omega$$



$$i_i = -g_m v_{be} \cdot \frac{R_C}{R_C + R_P}$$

$$i_u = \frac{v_u}{R_{B1} \| R_{B2} \| r_\pi}$$

$$V_i = -g_m v_{be} \cdot R_C \| R_P = \underbrace{-g_m R_C \| R_P}_{a_v = -52{,}4} \cdot v_u$$

$$\frac{i_i}{i_u} = \frac{-g_m \frac{R_C}{R_C + R_P}}{\frac{1}{R_{B1} \| R_{B2} \| r_\pi}} = -g_m \cdot R_C \cdot \overbrace{R_{B1} \| R_{B2} \| r_\pi}^{909{,}1} \cdot \frac{1}{R_C + R_P} = -12{,}2$$

$$R_{1L} = 465{,}55 \Omega$$

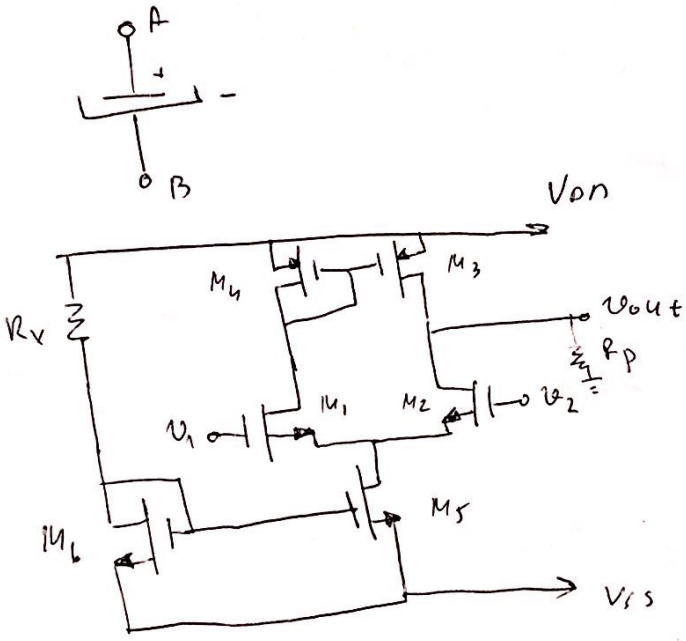
$$R_{2L} = 2 k\Omega$$

(5)

$V_{eff} = 220\,V$

$V_{max} = 220\sqrt{2}\,V$

$$\frac{220\sqrt{2}}{20} = \cancel{11} = 11\sqrt{2} = 15{,}56$$



$I_{D6} = I_{D5} = 500\mu A$

$I_{D4} = I_{D3} = I_{D1} = I_{D2} = 250\mu A$

$g_{m5} = g_{m6} = 1m\,S$

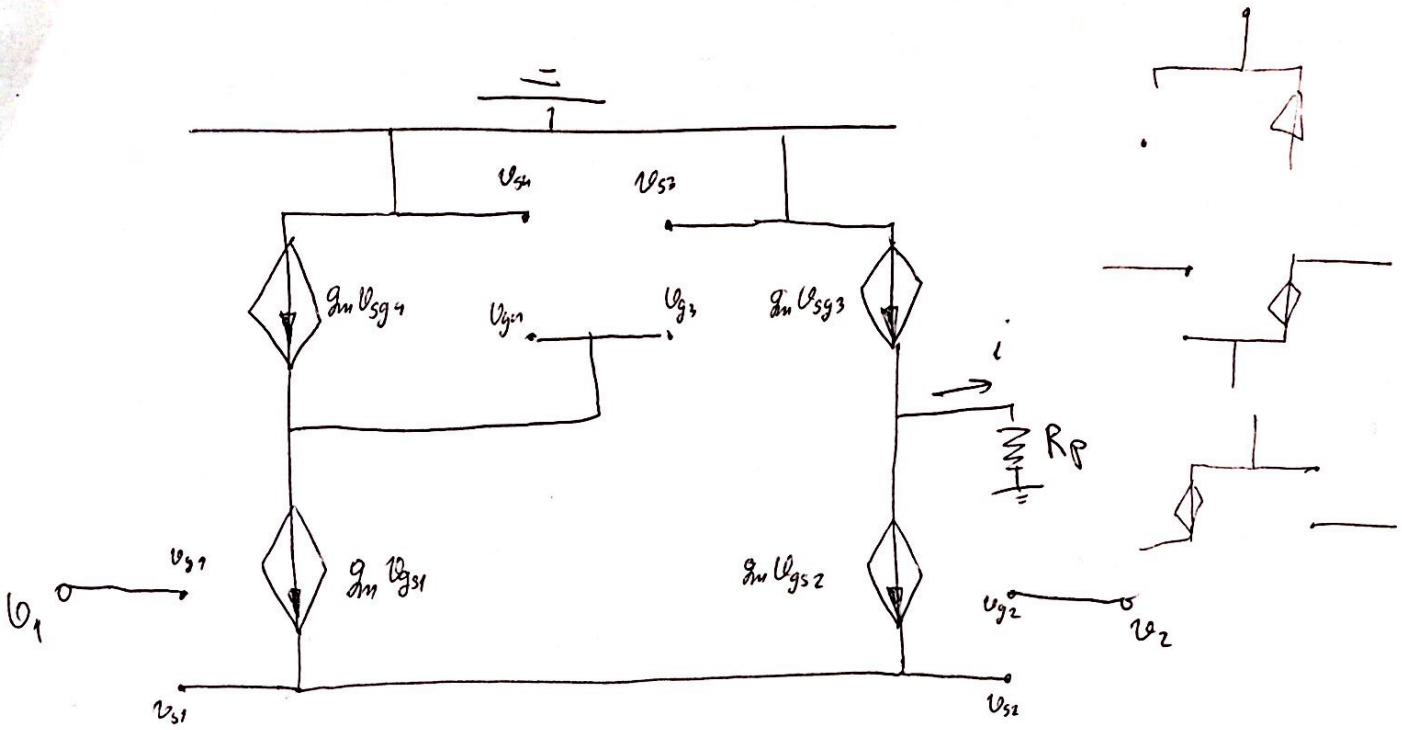
$g_{m4} = g_{m3} = g_{m1} = g_{m2} = 0{,}5m\,S$

$$v_{out} = 0V$$

$$I_D = \frac{B}{2}(v_{gs} - V_t)^2$$

$$v_g = V_s + \sqrt{\frac{2I_D}{B}} + V_t = -3V$$

$$\frac{V_{DD} + 3V}{500\mu A} = R_x = 16\,k\Omega$$



$g_m v_{gs1} = - g_m v_{gs2}$

$g_{m3} v_{sg3} = g_m v_{gs2} + i$

$i = g_{m3} v_{sg3} - g_m v_{gs2}$

$v_1 - v_s = - v_2 + v_s$

$v_1 + v_2 = 2v_s$

$v_s = \frac{v_1 + v_2}{2}$

$g_{m4} v_{sg4} = g_m v_{gs1} = g_{m3} v_{sg3}$

$g_{m4} v_{sg4} = g_{m3} v_{sg3}$

$i = g_m v_{gs1} - g_m v_{gs2} =$

$= g_m (v_1 - v_s - v_2 + v_s) = g_m v_d$

$v_{out} = g_m \cdot R_p \cdot v_d$

$$A_d = g_m R_p$$