Question A

1. 3.4 uA

I_{tot} = eff. I_{tot}

$I \cdot Q = flux \cdot e$

$P_{lum} = flux \cdot E$

0.01 cm^2

4.5×10^{15} photons / s · cm^2 → $4.5 \cdot 10^{13}$

3.4×10^{-6} A → Coulomb / s

$\frac{3.4 \times 10^{-6}}{1.6 \times 10^{-19}} = 2.125 \times 10^{13}$ Photons / s

$2.125 \times 10^{13} = x \cdot 4.5 \cdot 10^{13}$

$x = 0.47$

$x = 47\%$

2. ?

Question B :

1. 0.050 A

21 V

43%

$P_{tot} = P_{elec} + P_{lum}$

$P_{lum} = P_{tot} \cdot \Omega$

$P_{lum} = 0.05 \cdot 21 \cdot 0.43$

$P_{lum} = 0.04515$

$P_{lum} = 45$ mW

2. $P_{lum} = flux \cdot E$

$I \cdot Q = flux \cdot e$

$flux = \frac{P_{lum}}{E}$

$flux = \frac{0.045}{\frac{1.985 \cdot 10^{-16}}{550}}$

$\frac{\left(\frac{0.045 \cdot 1.602 \cdot 10^{-19}}{\frac{1.985 \cdot 10^{-16}}{550}}\right)}{0.05} = \Omega$

$\Omega = 0.3994 = 40\%$

Question C:

1. $6.6 \cdot 10^{-4}$

$n_p = n_i^2$

$n_i = 1.5 \times 10^{4}\ /cm^3$

$\rho = \frac{1}{q \cdot (\mu_p \cdot n \cdot \mu_n)}$ On peut dire que $p \approx 0$

$\rho = \frac{1}{q \cdot (n \cdot \mu_n)}$

$6.6 \cdot 10^{-11} = \frac{1}{1.602 \cdot 10^{-19} \cdot (n \cdot 950)}$

$n = 9.45 \cdot 10^{16}$

$10 \cdot 10^{16}$ ou 10^{17}

une électron pour nmcs

2. Ouais on peut négliger

3. 0,00066

Question D

1. $N_a = 10^{16}$

$N_d = 10^{17}$

$C_{j0} = 52.6 \cdot 10^{-12}$

$V_R = 9$

$m = 1/3$

$C_j = C_{j0} / \left(1 + \frac{V_R}{V_0}\right)^m$

$C_j = \frac{52.6 \cdot 10^{-12}}{\left(1 + \frac{9}{0.7543}\right)^{1/3}}$

$C_j = 1.46 \cdot 10^{-11}$

$V_0 = V_t \ln\left(\frac{N_a N_d}{n_i^2}\right)$

$V_0 = 0.0259 \cdot \ln\left(\frac{10^{16} \cdot 10^{17}}{(1.5 \cdot 10^{10})^2}\right)$

$V_0 = 0.754277$

Question 1:

a) $\beta = 30$ I_B V_B $V_T = 26\,mV$ I_C V_C $|V_{BE}| = 0,7\,V$ I_E V_E

$I_B = 33.7\,\mu A$ $V_B = 0$
$I_C = 1\,mA$
$I_E = 1\,mA$

$0 - V_{BE} - V_{R2} - V_{MM} = 0$
$0 - V_{BE} - R2\,I_B(\beta+1) - V_{MM} = 0$
$0 - 0,7 - 2200 \cdot I_B(30+1) - -3 = 0$
$I_B = 0.0000337 = 33.7\,\mu A$
$I_E = I_B(\beta+1) = 0.00104 = 1\,mA$
$I_C = I_E - I_B = 0.00104 - 0.0000337 = 0.0010062\,8$

$-3 + R_2 I_E = V_E$
$-3 + 2200 \cdot 0.00104 = -0,712\,V = V_E$

$3 - R_1 I_C = V_C$
$3 - 2200 \cdot 0.0010062\,8 = 0,786\,184 = V_C$

b) $V_{BB} - V_{R3} - V_{BE} = 0$
$3 - R3\,I_B(\beta+1) - 0.7 = 0$
$I_B = 74\,mA$
$I_E = I_B(\beta+1) = 0.0023 \cdot 23\,mA$
$I_C = I_E - I_B = 0.0023 - 0.074 = 2.23\,mA$

$I_B = 74\,\mu A$ $V_B = 0$
$I_C = 2.23\,mA$ $V_E = 0.7$
$I_E = 23\,mA$ $V_C = -0,774$

$V_E = -0.7$ $V_{BE} = V_B - V_E$
$V_B = 0$
$V_C = -3 + 1 \cdot 0.002226 = -0,774$

c) $I_D = 0.00115\,A$ $V = RI$ $R = 3043.478\,\Omega$
$V_T = -0.7\,V$ $\frac{3.5}{0.00115} = 3043.478$
$\mu_n C_{ox} = 60\,\mu A/V^2$
$L = 0.8\,\mu m$
$\lambda = 0$
$V_D = 3.5$

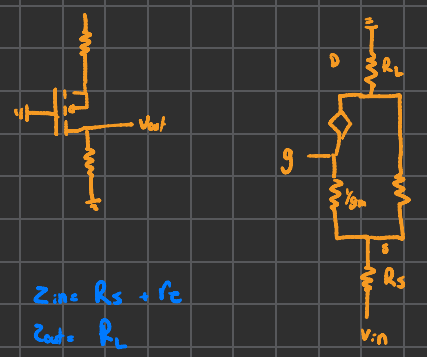
$I_D = \frac{1}{2} K (V_{GS} - V_T)^2$
$0.00115 = \frac{1}{2} K ((3.5 - 5) - -0.7))^2$
$K = 0.00359375$

$K' = \mu_n C_{ox}$
$K = K'\left(\frac{W}{L}\right)$
$0.00359375 = 60 \cdot \left(\frac{W}{0.8}\right)$
$W = 47.916\,\mu m$

Question 2

$I_D = 2A$
$V_{GS} = 4V$
$V_{BE} = 0.9\,V$

Question 3:



$V_{out} = -R_L I_D = 0$
$V_{out} = -R_L g_m V_\pi$
$V_{in} = -I_3 R_S - V_\pi$
$V_{in} = -g_m V_\pi R_S - V_\pi$

$\frac{V_{out}}{V_{in}} = \frac{-R_L g_m V_\pi}{-g_m V_\pi R_S - V_\pi}$ $\frac{-V_\pi}{-V_\pi}\left(\frac{R_L g_m}{g_m R_S + 1}\right)$

$Z_{in} = R_S + r_e$
$Z_{out} = R_L$

Question 4:

V_{GS} V_B I_G
V_{DS} V_C I_C
$I_D = I_S$ V_E I_E

$V_{GS} = 2.1968\,V$
$V_{DS} = 7.6968\,V$
$I_D = 2.2930\,mA$
} on a prouvé qu'il est en actif

$V_G = 10 \cdot \frac{1.8}{4} = 4.5$
$V_D = 10$
$V_{GS} = V_G - V_S$

$K = K'\left(\frac{W}{L}\right)$
$K = 100 \cdot \frac{32}{1}$
$K = 3200 \cdot 10^{-6}\,A$

$g_m = K(V_{GS} - V_t)$
$0.00332 = 3200 \cdot 10^{-6}(V_{GS} - 1)$
$V_{GS} = 2.1968$

$0.00383 = \sqrt{2 \cdot 3200 \cdot 10^{-6} I_D}$
$I_D = 2.2930\,mA$

$V_{DS} = V_D - V_S$
$V_{DS} = 10 - (V_G - V_{GS})$
$V_{DS} = 10 - 4.5 + 2.1968$
2.3032

$V_s = V_B = 2.3032\ V$

$V_C = 10 - R_C I_C$

$V_E = 0 + R_e I_E$

$V_s - V_{BE} - R_e I_E = 0$

$2.3032 - 0.7 - 39 \cdot I_B(101) = 0$

$I_B = 40.70\ \mu A$

$I_C = 4.07\ mA$

$I_E = 4.11\ mA$

$V_C = 10 - 390 \cdot 0.00407 = 8.4127$

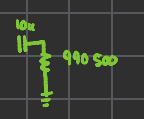
$V_E = 0 + 390 \cdot 0.00411 = 1.6029$

$V_B = 2.3032$ $\quad I_B = 40.70\ \mu A$

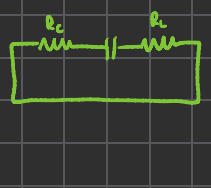
$V_C = 8.4127\ V$ $\quad I_C = 4.07\ mA$

$V_E = 1.6029\ V$ $\quad I_E = 4.11\ mA$

b) $R_1 // R_2$ $\quad \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}} = \frac{1}{\frac{1}{22k\Omega} + \frac{1}{1M\Omega}} = 990\,000$



$\frac{1}{2\pi \cdot 990\,500 \cdot 10 \cdot 10^{-6}} = 16\ mHz$



$\frac{1}{2\pi \cdot 2190 \cdot 10 \cdot 10^{-6}} = 7.26\ Hz$

c)

Question 5:

a)

b) $Z_{in} = r_e // R_C$ $\quad V_{in} = r_e \cdot -I_e$

$Z_{out} = R_C // R_L$ $\quad V_{out} = \alpha I_c (R_c // R_L)$

$\frac{\alpha I_E (R_c // R_L)}{r_e I_E} = \frac{\alpha (R_c // R_L)}{r_e}$ $\quad \frac{\alpha}{r_e} = g_m$

$g_m (R_c // R_L)$

c) $r_c \uparrow$ $\quad r_L \uparrow$ $\quad r_o \uparrow$ $\quad g_m \uparrow$

Question 4 :

$\vec{I} \cdot \vec{\Theta} = \Phi_{ux} \cdot \vec{e}$

$3,4 \cdot 10^{-6} \cdot \Theta = 4,5 \cdot 10^{-13} \cdot 1,602 \cdot 10^{-19}$