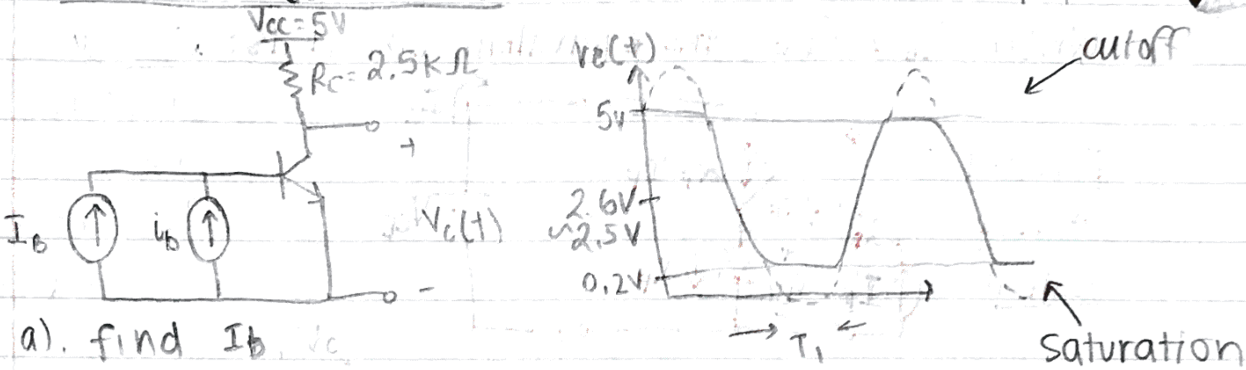
MIDTERM SOLUTIONS 5/4/18

PROBLEM 3.



a). find I_B

$i_b = -I_o \sin \omega t$

$I_o > I_B$ ← causes cutoff

bias voltage → $2.5 = V_{CC} - R_C I_C$

$I_C = \frac{2.5}{2.5k\Omega} = 1mA$

↳ $I_B = 10\mu A$

b). plot $V_C(t)$ if $I_o = 8.8 mA$ and $I_B = 10\mu A$

$I_b = I_B - I_o \sin \omega t$

assume FA mode

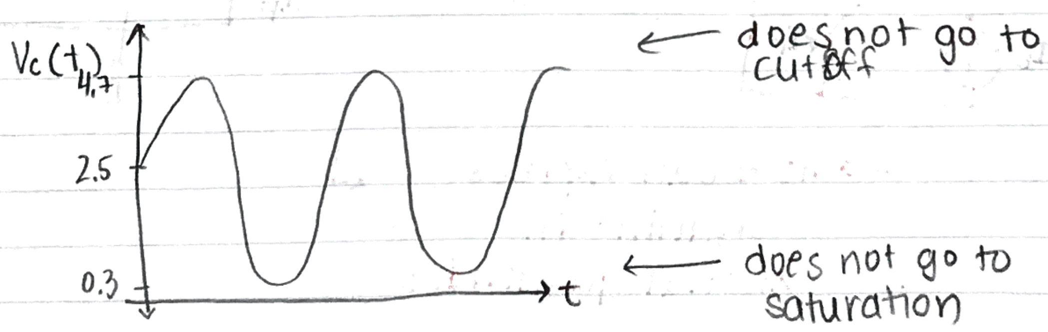
$I_C = \beta I_B = 1mA$

↳ $V_C = V_{CC} - I_C R_C$

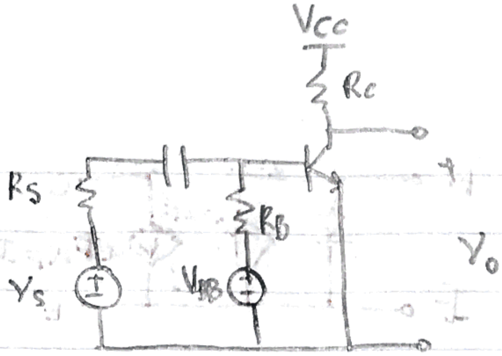
$V_{Cmin} = V_{CC} - I_{Cmax} R_C$
$= V_{CC} - (1.58mA)(2.5k\Omega)$
$= 0.3V$

$V_{Cmax} = V_{CC} - I_{Cmin} R_C$
$= 4.7 V$

since $I_o < I_B$, won't go into cutoff or saturation



Problem 4



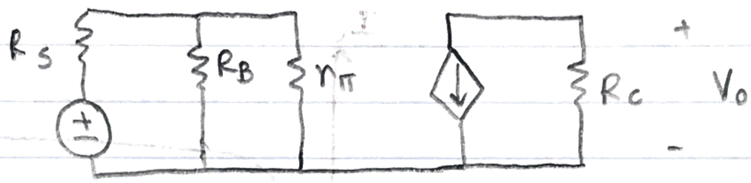
V_{BE} is biased optimally

$R_B, R_C \sim \times 10 R_S$

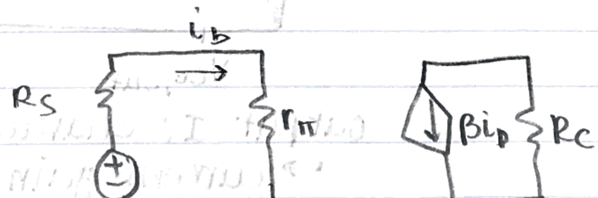
prove $\frac{V_o}{V_s} \approx \frac{-V_{CC}}{2V_T}$

optimum bias point ↳ $\frac{1}{2}V_{CC} = V_{CC} - I_C R_C \rightarrow I_C = \frac{V_{CC}}{2R_C}$

small signal equivalent:



↓ can neglect R_B



$i_b = \frac{V_s}{R_S + r_\pi}$

$V_o = -\beta i_b R_C$

$\frac{V_o}{V_s} = \frac{-1}{R_S + r_\pi} \beta R_C$

$\frac{V_o}{V_s} = -\frac{1}{R_S + \frac{V_T}{I_B}} \beta R_C$

$I_B = \frac{I_C}{\beta}$

$\frac{V_o}{V_s} = -\frac{1}{R_S + \frac{V_T \beta 2 R_C}{V_{CC}}} \beta R_C$ ← this is equal to R_C

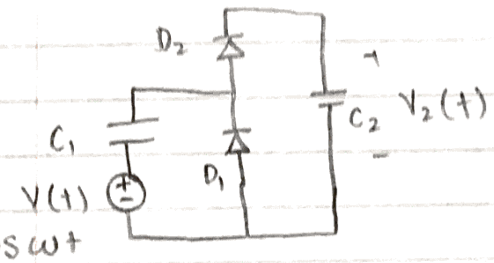
$$\frac{v_o}{v_s} = -\frac{1}{R_S + R_C}\beta R_C = -\frac{\beta R_C}{R_C} = -\beta$$

gain is 100 ← this is equal to $\frac{V_{CC}}{2V_T}$

to get the expression:

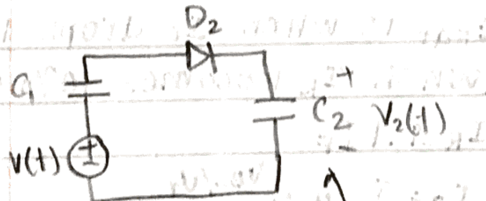
$$\frac{v_o}{v_s} = -\frac{\beta R_C}{r_\pi} = -\frac{\beta R_C}{\frac{R_C\, 2V_T\, \beta}{V_{CC}}} = -\frac{V_{CC}}{2V_T}$$ ← this is what we wanted

Problem 1:



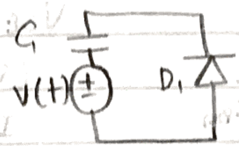
Plot $V_2(t)$ in steady state.

when $v(t) > 0$



↑ C_2 is always charging

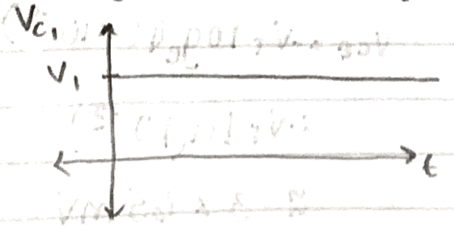
when $v(t) < 0$

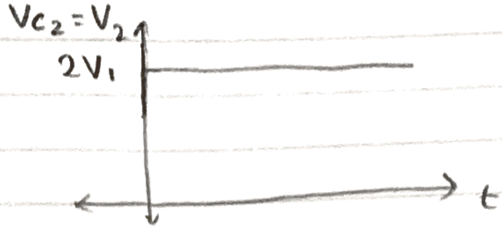


← C_1 is getting discharged

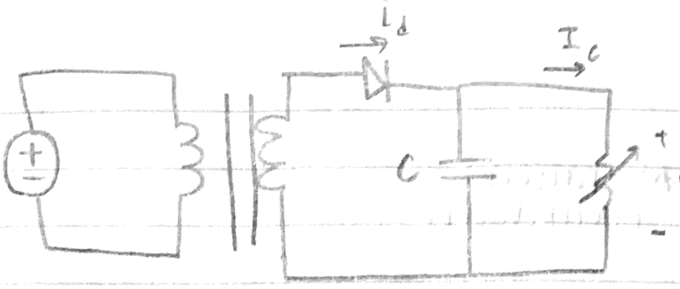
max voltage across C_1 : V_1
max voltage across C_2 : $2V_1$

steady state for V_2 must be constant since it is always being charged





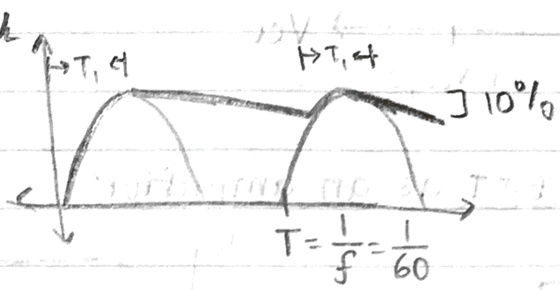
Problem 2



$V_L = 15.6 \pm 5\%$

I_c: 0 - 100 mV

a). calculate the smallest C.



$R_L > 156\,\Omega$

$e^{-t/R_LC} \geq 0.9$

$1 - \frac{T}{R_LC} \geq 0.9$

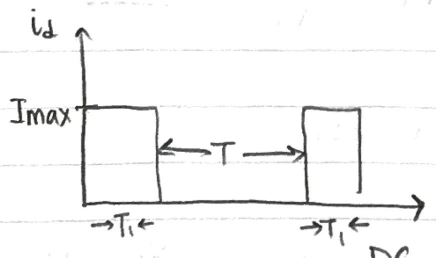
$R_LC > 10T$

$C > \frac{10T}{R_{L_{min}}}$

$C > \frac{10T}{156}$

b). i_d

$i_d(t) = I_L$ at DC



diode only conducts during T_1, when diode is on

DC

$I_{max} T_1 = I_L T$

$\cos\theta = 0.9$

$\hookrightarrow \theta$

$\frac{\theta}{2\pi} = \frac{T_1}{T} \rightarrow \frac{T_1}{T} = \frac{I_L}{I_{max}} = \frac{\theta}{2\pi}$