TEST 2 EXAMPLE 2 SOLVED

1.

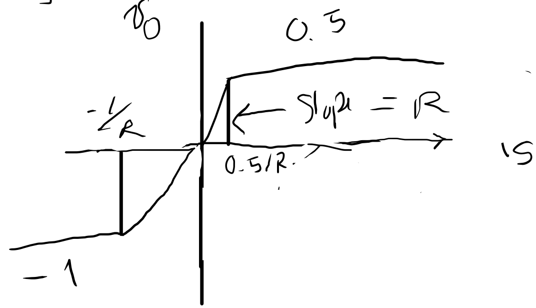
a) $I_S = 1mA \Rightarrow$ LED OFF $\qquad R = R_2 // R_3 = 2k\Omega$

If D_1 also OFF $v_0 = R\,I_S = 4V$ but this is impossible because $V_{D1} \leq 0.5$

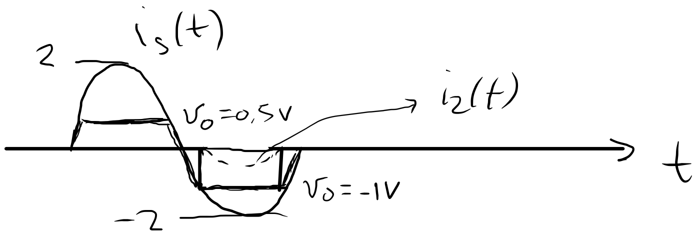
So $v_0 = V_{D1\,ON} = 0.5V$

$I_S = 1mA \Rightarrow D_1$ OFF LED ON $v_0 = -V_{LED\,ON} = -1V$
(same reasoning)

b)



c) $i_s(t) = 2\sin(\omega t)$ mA



d) Max current in D_1 $= I_{S_{max}} - \dfrac{V_{D1ON}}{R_2 // R_3} = I_{D1MAX}$

Max power in D_1 $= V_{D1ON} \times I_{D1MAX}$

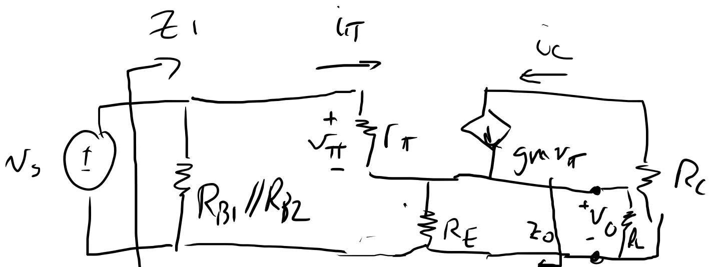
Max current in LED $= I_{LEDMAX} = I_{SMAX} - \dfrac{V_{LEDON}}{R_3 // R_2}$

Max power in LED $= V_{LEDON} \times I_{LEDMAX}$

2. R_{B2} is meant between <u>base</u> and V_{CC} negative terminal (typo R_{B1}). Capacitors are open at O.P.

$V_B = V_E + 0.7$, $I_E = \frac{V_E}{R_E}$, $I_B = \frac{I_E}{1+\beta}$, $I_{B1} = \frac{V_{CC} - V_B}{R_{B1}}$

$I_{B2} = \frac{V_B}{R_{B2}}$, $I_{B2} = I_{B1} - I_B \Rightarrow \boxed{R_{B2} = \frac{V_B}{I_{B1} - I_B}}$



$g_m v_\pi = \beta i_\pi$

$v_o = R_E // R_L \; i_E$

$i_E = (1+\beta) i_\pi$, $i_\pi = \frac{v_s}{r_\pi + (1+\beta) R_E // R_L}$

$Av = \frac{v_o}{v_s} = R_E // R_L (1+\beta) \frac{1}{r_\pi + (1+\beta) R_E // R_L}$

$Z_1 = R_{B1} // R_{B2} // (r_\pi + (1+\beta) R_E)$

$Z_o = \frac{v_o}{i_E - i_\pi - i_C}$ (NO R_L!) ($v_s = 0$!)

$i_E = \frac{v_o}{R_E}$, $i_\pi = \frac{-v_o}{r_\pi}$

$i_C = \beta i_\pi$

c) $\omega_L = \frac{1}{R_{eq} C_O}$, $R_{eq} = R_L + Z_o$

3. a) $V_A = 2V$, $V_B = 5V$, use Superposition, switch = 1.

inverting and non inverting amp formulae

$$v_O = -\frac{R_F}{R_A} v_A + \frac{R_{B2}}{R_{B1}+R_{B2}}\left(1+\frac{R_F}{R_A}\right) v_B$$

$$= -2 \times 2 + \frac{0.2}{2.2} \times 3 \times 5 \ V \text{ (no saturation)}$$

b) Switch = 2 $\Rightarrow$ D_{OFF} and $V_D = \frac{2}{2.2} V_B$ (< 0)

$V_A = 3V$, $V_B = -1V$ Using eq. (3a) $v_o < -5V$ which is impossible as OP-AMP saturates at $v_O = -5V$ //

c) Superposition, switch = 2

$V_A = -1V$, $V_B = 2\cos\omega t$ V

$V_{oA} = -1 \times -2 = +2V$

$v_o = v_{oA} + v_{oB}$

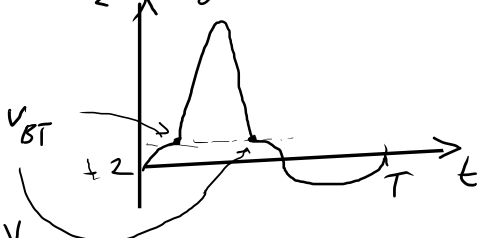
D OFF: $V_{oB} = \frac{R_{B2}}{R_{B1}+R_{B2}}\left(1+\frac{R_F}{R_A}\right)V_B$ as before

D ON: $V_{oB} = \left(1+\frac{R_F}{R_A}\right)\left(V_B - 0.7\right)$

Diode switches on when $V_{RB1} = 0.7V$ that is

when $\underbrace{\frac{R_{B1}}{R_{B1}+R_{B2}} V_B}_{V_{RB1} \text{ with diode off}} \geq 0.7V \Leftrightarrow V_B \geq 0.7\times\frac{2.2}{2}$ V

$$v_o(t) = \begin{cases} +2 + \frac{0.2}{2.2}\times 3\, v_B(t), & v_B < 0.7\times\frac{2.2}{2}V = V_{BT} \\ +2 + 3(v_B - 0.7), & v_B \geq 0.7\times\frac{2.2}{2}\text{ V} \end{cases}$$



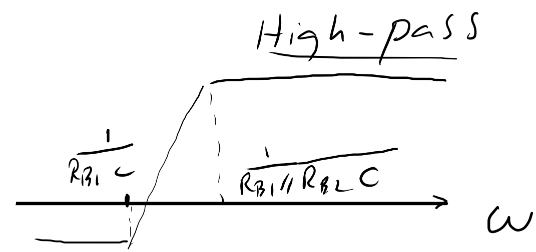
d) $\underline{\text{switch} = 3}$, $V_A = -1V$, $v_B = \cos(\omega t)$, $f = 1kHz$

superposition $v_0 = v_{OA} + v_{OB} = -2 + v_{OB}$

$$V_{OB}(s) = \left(1 + \frac{R_F}{R_A}\right) \frac{R_{B2}}{R_{B1} // \frac{1}{sC} + R_{B2}} V_B(s)$$

make $s = j\omega = j2\pi f$ and compute $\frac{v_{OB}(j\omega)}{v_B(j\omega)} = T$

$$v_0(t) = |T| \cos(\omega t + \angle T)$$



$$T(s) = \frac{R_{B2} \times 3}{\frac{R_{B1}/sC}{R_{B1} + \frac{1}{sC}} + R_{B2}} = \frac{R_{B2} \times 3}{\frac{R_{B1}}{1 + R_{B1} C s} + R_{B2}} = \frac{3R_{B2}(1 + R_{B1} C s)}{R_{B1} + R_{B2}(1 + R_{B1} C s)}$$

$$= \frac{3R_{B2}(1 + R_{B1} s C)}{R_{B1} + R_{B2} + R_{B1} R_{B2} C s} = \frac{3R_{B2}}{R_{B1} + R_{B2}} \frac{1 + R_{B1} C s}{1 + R_{B1} // R_{B2} C s}$$