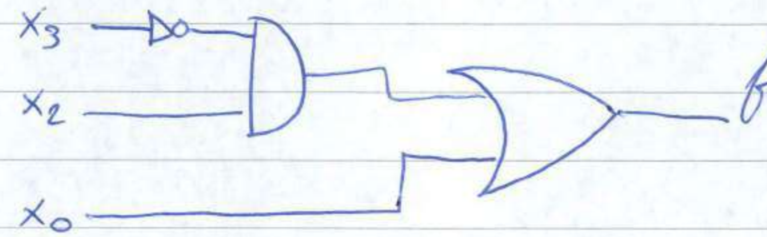
1TE 717 - EXAM MAY 31, 2018

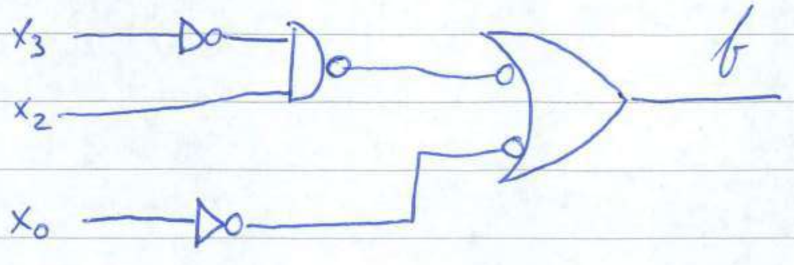
A.1

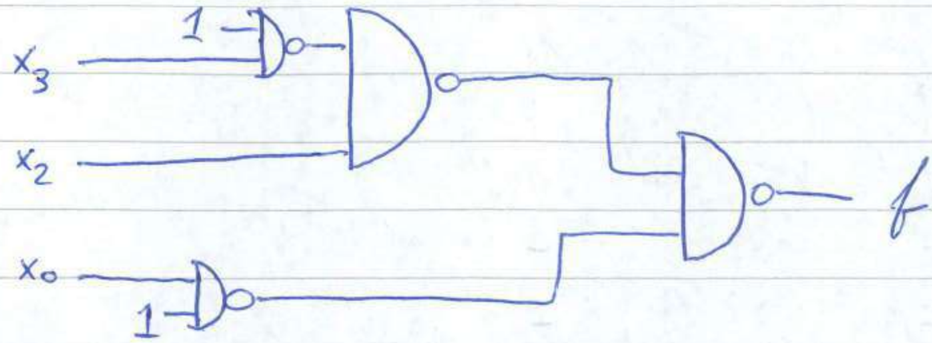
$$f(x_3, x_2, x_1, x_0) = \sum(0,2,4,5,6,7) + d(8,10,12,14).$$

x_3x_2 \ x_1x_0	00	01	11	10
00	1			1
01	1	1	1	1
11	-			-
10	-			-

$$f(x_3, x_2, x_1, x_0) = \overline{x_0} + \overline{x_3} \cdot x_2$$

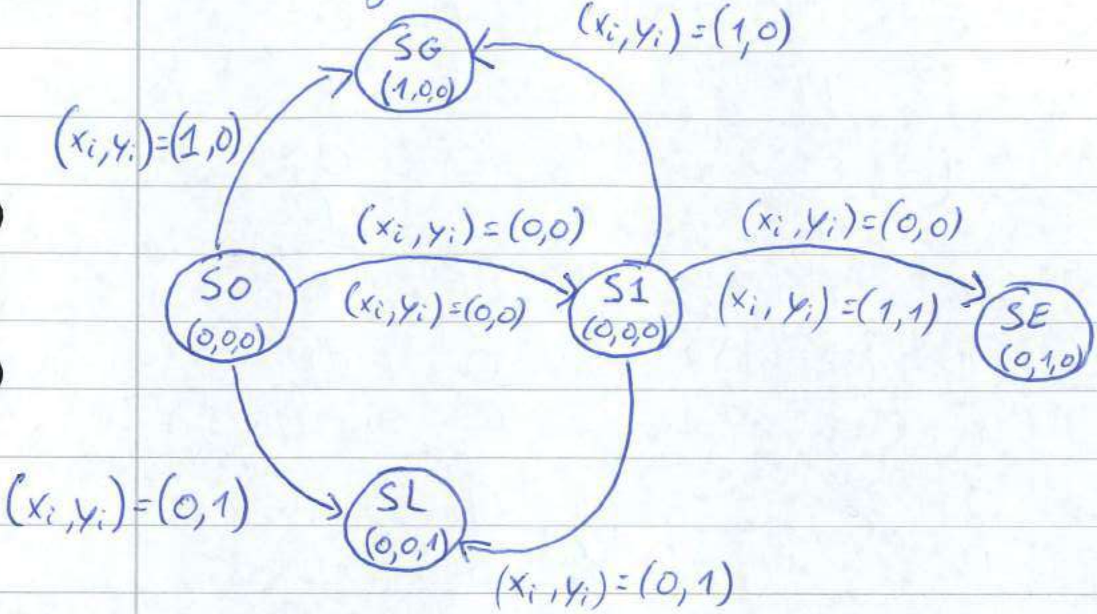





1
x_3
x_2
x_0
1
f

A.2

State diagram:



State coding (and output):

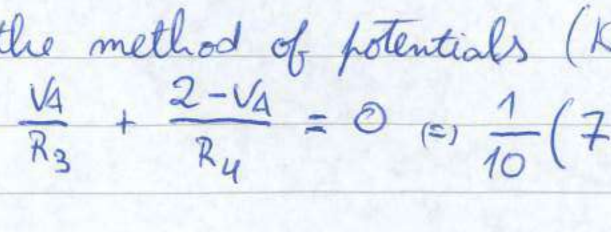
State	q_2	q_1	q_0	z_2	z_1	z_0
S0	0	0	0	0	0	0
S1	0	0	~~0~~1	0	0	0
SG	1	~~0~~1	~~0~~0	1	0	0
SE	1	0	0	0	1	0
SL	1	0	1	0	0	1

State transitions:

q_2	q_1	q_0	x_i	y_i	q_2^+	q_1^+	q_0^+
0	0	0	0	0	0	0	1
0	0	0	0	1	1	0	1
0	0	0	1	0	1	1	0
0	0	0	1	1	0	0	1
0	0	1	0	0	1	0	0
0	0	1	0	1	1	0	1
0	0	1	1	0	1	1	0
0	0	1	1	1	1	0	0
–	–	–	–	–	–	–	–
1	0	0	–	–	1	0	0
1	0	1	–	–	1	0	1
1	1	0	–	–	1	1	0
–	–	–	–	–			

Implemented as a Moore machine with 3 D Flip-Flops.

A.3a)

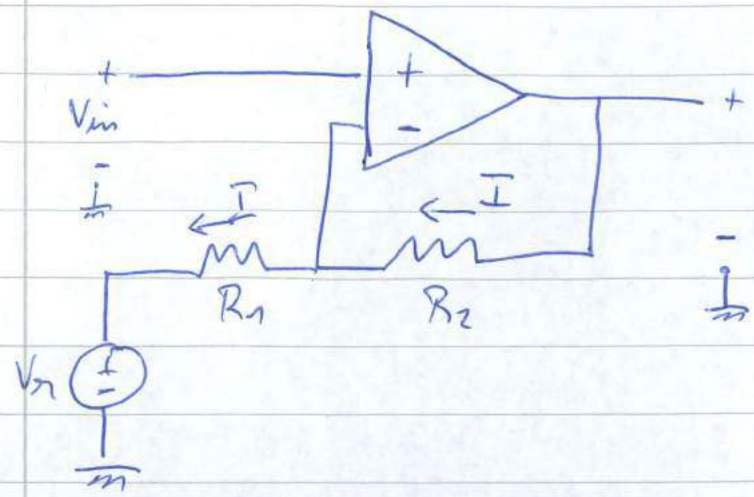


We can use the method of potentials (Kirchoffs' current law)

$$\frac{5-V_A}{R_1} - \frac{V_A}{R_2} - \frac{V_A}{R_3} + \frac{2-V_A}{R_4} = 0 \Leftrightarrow \frac{1}{10}(7-4V_A) = 0 \Leftrightarrow V_A = \frac{7}{4}V$$

$$I_{R_2} = \frac{V_A}{R_2} = \frac{7}{40}A$$

A.3.b)



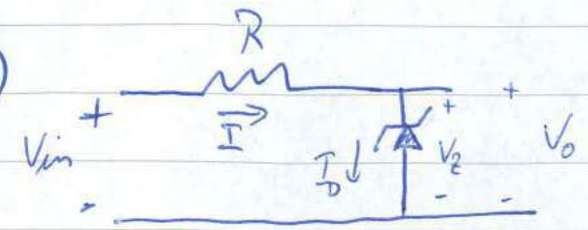
$$V_o = V_{in} + R_2 I$$
$$I = \frac{V_{in} - V_r}{R_1}$$
$$\Rightarrow \quad V_o = V_{in} + \frac{R_2}{R_1}(V_{in} - V_r)$$

$$\therefore \quad V_o = \left(1 + \frac{R_2}{R_1}\right) V_{in} - \frac{R_2}{R_1} V_r$$

$$= 3 V_{in} - 4$$

A.4

a)

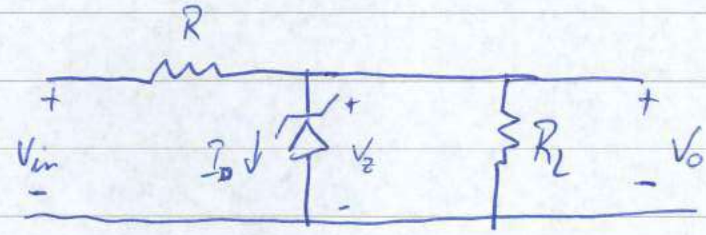


$$I_D = I = \frac{V_{in} - V_z}{R} = \frac{9-5}{R}$$

$$I_D < 20\,mA \Leftrightarrow \frac{4}{R} < 20 \times 10^{-3} \Leftrightarrow$$

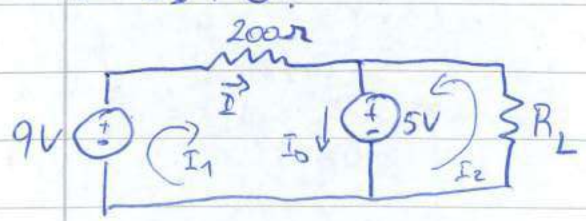
$$R > \frac{4}{20} \times 10^{3} = 200\,\Omega$$

b)



$$V_o = V_z = \begin{cases} 5V, \text{ if } I_D > 0 & \text{(Reverse conduction)} \\ \frac{R_L}{R+R_L} V_{in}, \text{ if } I_D = 0 & \text{(No conduction)} \end{cases}$$

$\therefore I_D > 0$



$$\begin{cases} 9 - 200 I_1 - 5 = 0 \\ - R_L I_2 - 5 = 0 \\ I_D = I_1 + I_2 \end{cases} \Leftrightarrow \begin{cases} I_1 = \frac{4}{200} = 20\ mA \\ I_2 = - \frac{5}{R_L} \\ I_D = 0.02 - \frac{5}{R_L} \end{cases}$$

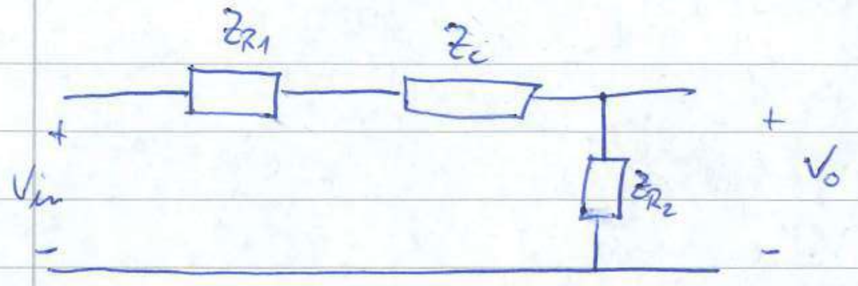
$$I_D > 0 \Leftrightarrow 0.02 > \frac{5}{R_L} \Leftrightarrow R_L > \frac{5}{0.02} = 250\,\Omega$$

A.5

$$V_{in}(t) = 3\sin\left(20\times10^{3}\pi t - \frac{\pi}{2}\right) =$$
$$= \mathrm{Im}(V_{in}) = \mathrm{Im}\left(3\, e^{-j\frac{\pi}{2}}\, e^{j2\times10^{4}\pi t}\right)$$

$V_{in} = 3\, e^{-j\frac{\pi}{2}}$ (the phasor of the complex voltage)

$\omega = 2\times10^{4}\pi$ rad/s



$$Z_{R_1} = R_1 \quad , \quad Z_{R_2} = R_2 , \quad Z_c = \frac{1}{j\omega C}$$

$$V_o = \frac{Z_{R_2}}{Z_{R_1} + Z_{R_2} + Z_c} V_{in} = \frac{R_2}{R_1 + R_2 + \frac{1}{j\omega C}} V_{in} =$$

$$= \frac{j\omega R_2 C}{1 + j\omega(R_1+R_2)C} V_{in}$$

$R_1 = R_2 = 500\,\Omega$
$C = 0.1\,\mu F = 10^{-7}\,F$
$\omega = 2\times10^{4}\pi$ rad/s

$$V_o = \frac{j\,2\pi\times10^{4}\times500\times10^{-7}}{1 + j\,2\pi\times10^{4}\times10^{3}\times10^{-7}} V_{in} = \frac{j\pi}{1+j2\pi} \times V_{in}$$

$$\frac{j\pi}{1+j2\pi} = \left|\frac{j\pi}{1+j2\pi}\right| e^{j\arg\left(\frac{j\pi}{1+j2\pi}\right)}$$

$$\left| \frac{j\pi}{1+j2\pi} \right| = \frac{\pi}{\sqrt{1+4\pi^2}}$$

$$\arg\left(\frac{j\pi}{1+j2\pi} \right) = \frac{\pi}{2} - \arctan(2\pi)$$

$$\therefore V_o = \frac{j\pi}{1+j2\pi} \times V_{in} = \frac{\pi}{\sqrt{1+4\pi^2}} e^{j\left(\frac{\pi}{2} - \arctan(2\pi)\right)} \times 3 e^{-j\pi/2}$$

$$V_o = \frac{3\pi}{\sqrt{1+4\pi^2}} e^{-j\arctan(2\pi)}$$

$$V_o(t) = \mathrm{Im}\left(V_o e^{j2\times10^4\pi t} \right) =$$

$$= \frac{3\pi}{\sqrt{1+4\pi^2}} \sin\left(2\times10^4\pi t - \arctan(2\pi) \right)$$