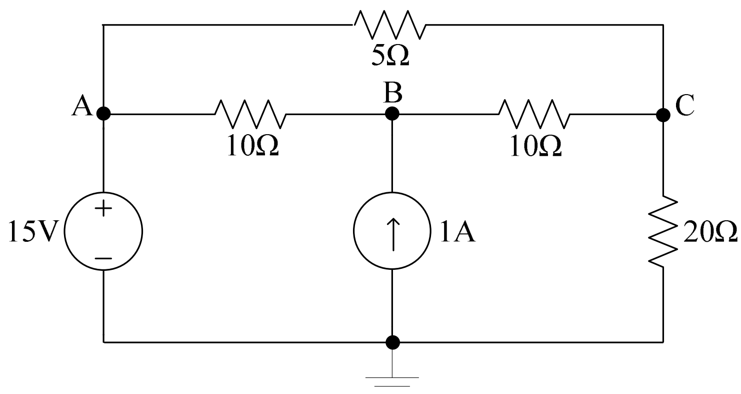
SP'11

Problem 1 *(20 points)*

Derive the three equations involving unknown voltages V_A, V_B and V_C that would result from applying the node voltage method to the following circuit.



Derive the appropriate equation for each node and enter the coefficients for each equation below.

Node A:

$\square\, V_A + \square\, V_B + \square\, V_C = \square$

Node B:

$\square\, V_A + \square\, V_B + \square\, V_C = \square$

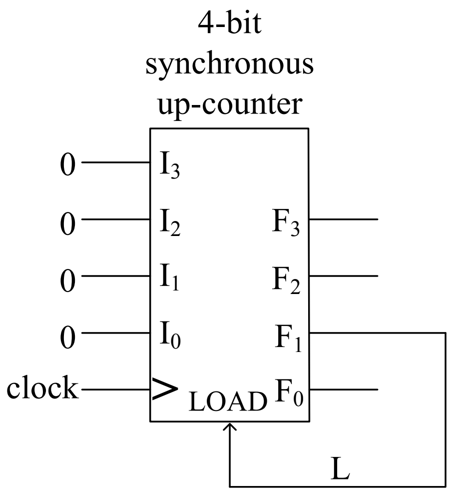
Node C:

$\square\, V_A + \square\, V_B + \square\, V_C = \square$

Problem 2 *(20 points)*

Multiple Choice - no need to show work.

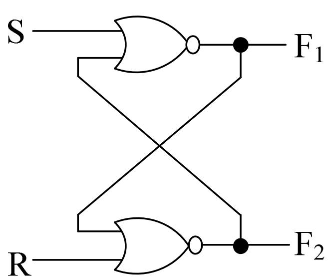
(a) *(5 pts)* What is the duty cycle of the signal "L"?



Pick one:

- [ ] 100%
- [ ] 50%
- [ ] 33.3%
- [ ] 25%
- [ ] 20%
- [ ] 10%
- [ ] 0%

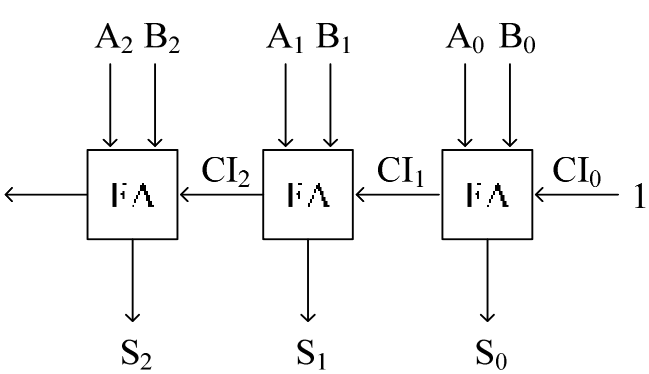
(b) *(5 pts)*



In this circuit, what is F_1 and F_2 while $S = 1$ and $R = 1$?

- [ ] $F_1 = 0, F_2 = 0$
- [ ] $F_1 = 1, F_2 = 0$
- [ ] $F_1 = 0, F_2 = 1$
- [ ] $F_1 = 1, F_2 = 1$
- [ ] No way to know for sure

(c) *(5 pts)*



If $A = 3$, $B = 6$, $CI_0 = 1$, then

- [ ] $S = 0$
- [ ] $S = 4$
- [ ] $S = 1$
- [ ] $S = 5$
- [ ] $S = 2$
- [ ] $S = 6$
- [ ] $S = 3$
- [ ] $S = 7$

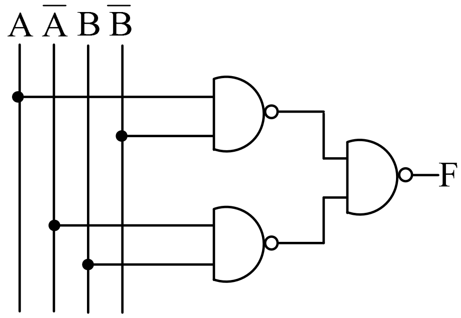
A is $A_2\ A_1\ A_0$, B is $B_2\ B_1\ B_0$, S is $S_2\ S_1\ S_0$

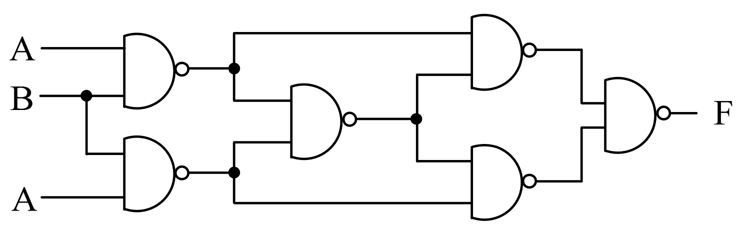
(d) *(5 pts)* The following is a Morse Code message with prefixes (time gap between letters) removed. Mark all the possible data that might be encoded:

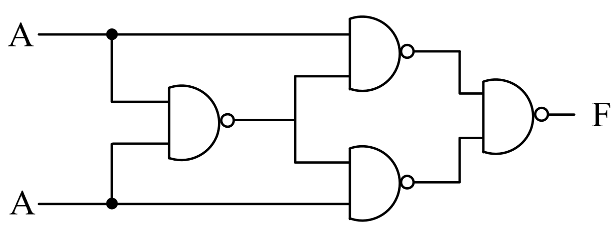
— • — •

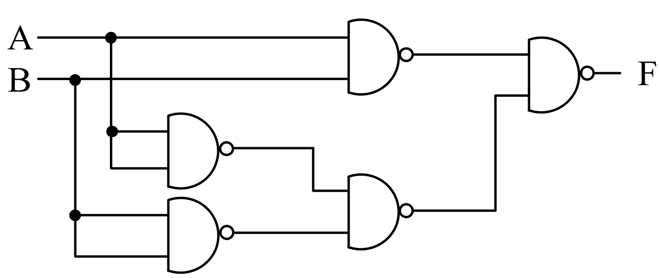
☐ TEN	☐ KE	☐ NN
☐ C	☐ TETE	☐ NTE
☐ TAE	☐ TR	☐ SOS

(e) *(5 pts)* Which of the following circuits correctly implement XOR, i.e. $F = A \oplus B$? (more than one circuit may work)

☐ 

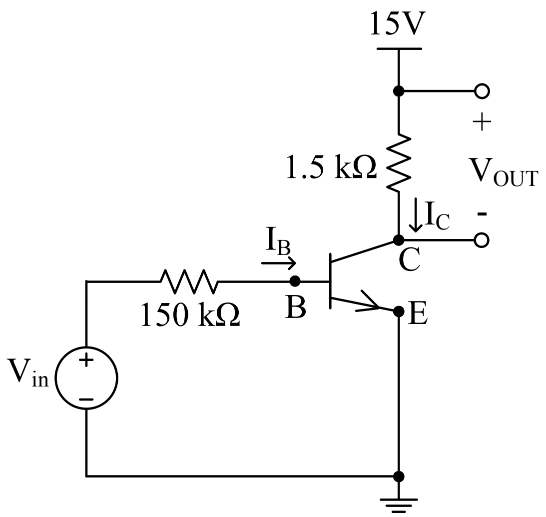
☐ 

☐ 

☐ 

Problem 3 *(20 points)*

The transistor in the following circuit has **β = 85, V_{BEON} = 0.7 V, and V_{CESAT} = 0.2 V**. **Show work**.



(a) *(4 pts)* Determine I_{CMAX}. (note labeling of V_{OUT})

I_{CMAX} = ☐ mA

(b) *(1 pt)* Check the correct answer:

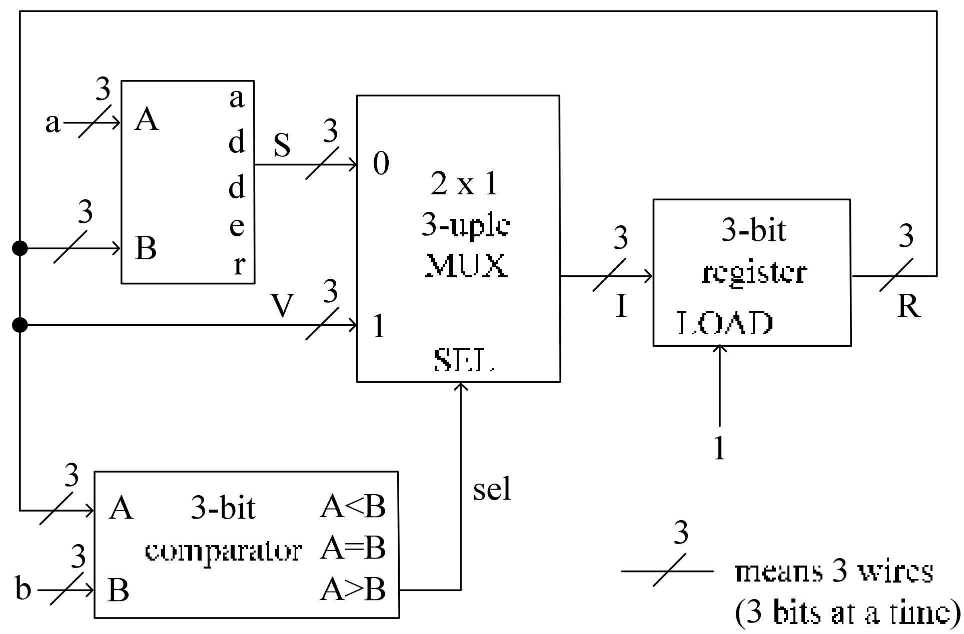
☐ $V_{out} = V_{CE}$

☐ $V_{out} \neq V_{CE}$

(c) *(15 pts)* Provide the missing values in the following table.

V_{IN} (V)	I_B (µA)	I_C (mA)	V_{OUT} (V)
2			
4			
20			

Problem 4 *(20 points)*



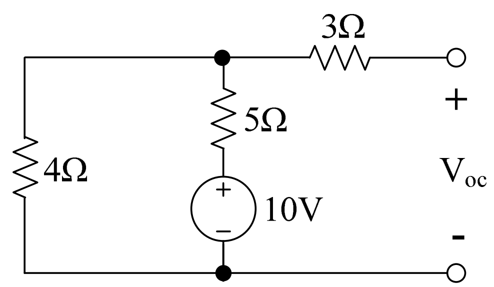
Notice that all binary numbers, except "sel" and "LOAD", are coded on 3 bits.

Provide all values in decimal in the table below for consecutive clock pulses.

clock pulse	0	1	2	3
R	3			
a	1	5	3	2
b	5	2	6	7
S				
sel				
I				

Problem 5 *(10 points)*

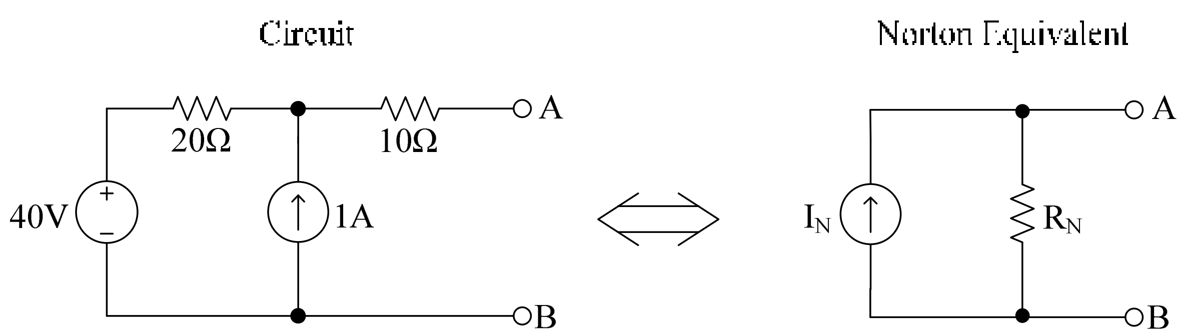
Find V_{oc} in the following circuit using the voltage divider rule (VDR). You must show work and use VDR for credit.



V_{oc} = [ ] V

Problem 6 *(10 points)*

Find the values (I_N and R_N) for the Norton equivalent for the circuit below.

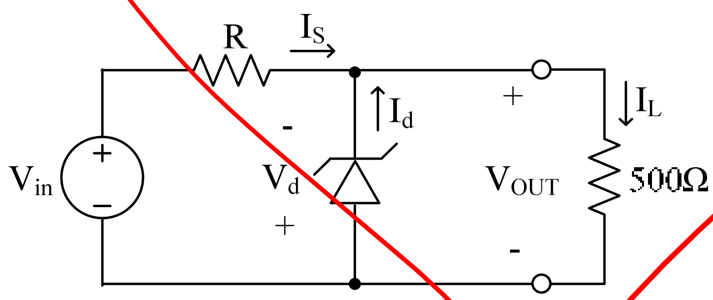


I_N = [ ] A R_N = [ ] Ω

Zener diodes no longer covered -

Problem 7 *(20 points)*

The Zener diode in the following circuit has a value for V_Z of 5 V.



(a) *(5 pts)* Determine the value of I_L if the diode is in breakdown.

$I_L =$ ______ mA

(b) *(5 pts)* Determine the value of I_L if the diode is off and I_S = 3mA.

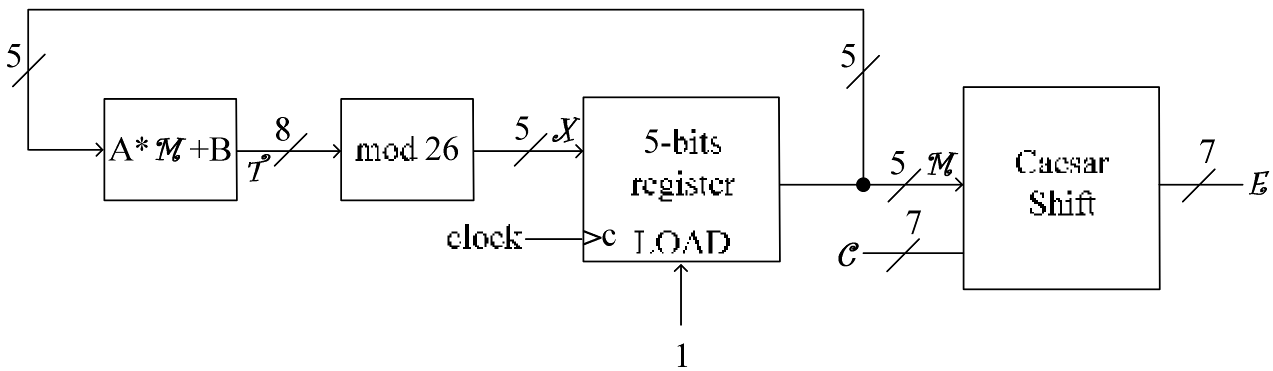
$I_L =$ ______ mA

(c) *(10 pts)* If V_{in} fluctuates between a low of 10 V and a high of 12 V, determine the maximum value for R that will allow the Zener diode to regulate the voltage V_{out} to the desired value of 5 V.

$R_{MAX} =$ ______ Ω

Problem 8 *(25 points)*

The circuit "ENCRYPT" below encrypts an ASCII message by performing a pseudo-random sequence of Caesar Shifts on each character $\mathcal{C}$ of a message; each clock pulse, one character gets treated (i.e. it is shifted by $\mathcal{M}$ positions to the right to produce another letter of the alphabet).



(a) *(6 pts)* Find the encrypted letter $\mathcal{E}$ for the two following independent cases (one example is given). The shift $\mathcal{M}$ is given in decimal for convenience.

$\mathcal{M}$	1	15	10
$\mathcal{C}$ (letter)	F	H	T
$\mathcal{C}$ (ascii)	1000110		
$\mathcal{E}$ (letter)	G		
$\mathcal{E}$ (ascii)	1000111		

(b) *(9 pts)* The two circuit portions on the left (A* $\mathcal{M}$ +B and mod 26) implement the pseudo-random generator:

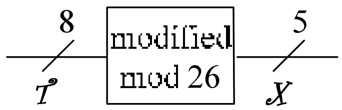
$\mathcal{X} = \mathcal{T}$ mod 26 with $\mathcal{T} = 7 * \mathcal{M} + 5$

The message "MANDY" is encrypted by the circuit "ENCRYPT" one character at a time. Provide all numbers in decimal ($\mathcal{M}$, $\mathcal{T}$, $\mathcal{X}$) for each clock pulse, and the resulting encrypted message (one character $\mathcal{E}$ each clock pulse):

clock pulse	$\mathcal{M}$	$\mathcal{C}$	$\mathcal{E}$	$\mathcal{T}$	$\mathcal{X}$
0	21	M			
1		A			
2		N			
3		D			
4		Y			

Problem 8 cont'd

(c) *(10 pts)* You will now implement a modified mod 26 circuit.



It still produces a number $\mathcal{X}$ between 0 and 25, but it is generated by the process:

- $\mathcal{Y} = \mathcal{T} \bmod 32$ ($\mathcal{Y}$ is coded on 5 bits)
- If $\mathcal{Y} \leq 25$, then $\mathcal{X} = \mathcal{Y}$
  If $26 \leq \mathcal{Y} \leq 31$, then $\mathcal{X} = 31 - \mathcal{Y}$

To give you an idea on how to design this circuit, do the following examples:

Example 1: (give binary numbers)

$\mathcal{T} = 44_{10}$ | | | | | | | | |

$\mathcal{Y} = 12_{10}$ | | | | | |

$\mathcal{X} = 12_{10}$ | | | | | |

Example 2: (give binary numbers)

$\mathcal{T} = 91_{10}$ | | | | | | | | |

$\mathcal{Y} = 27_{10}$ | | | | | |

$\mathcal{X} = 4_{10}$ | | | | | |

Draw the two missing circuits (use wires, AND, OR, NOT gates only), and fill the two missing MUX inputs. **Justify your design!**